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OPERATING & MAINTENANCE MANUAL

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MODEL 3S & 5S
X-Y RECORDER

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F. L. MOSELEY CO.
409 NO. FAIR OAKS AVENUE, PASADENA, CALIFORNIA

OPERATING & MAINTENANCE MANUAL

for

MODEL 3 S

X-Y RECORDER

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by

F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, California

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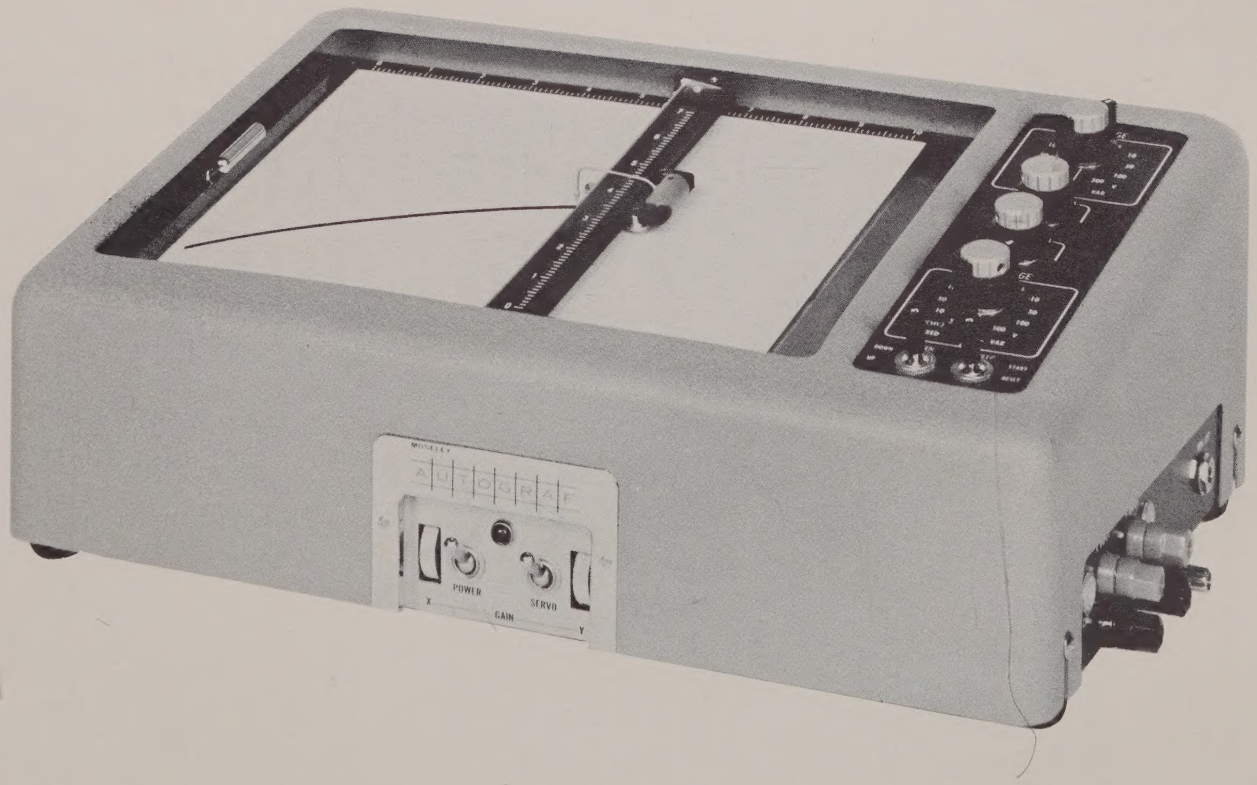
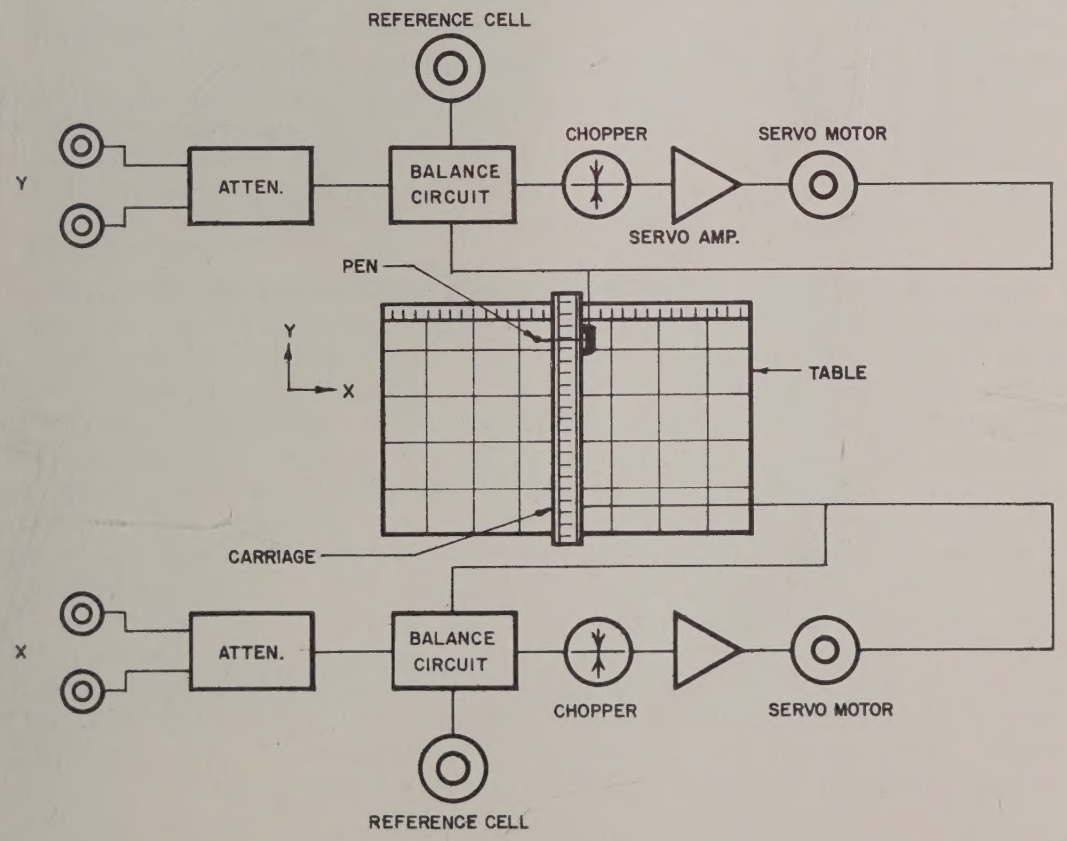


MODEL 3S AUTOGRAF
FIG. 1

A. GENERAL DESCRIPTION

The Autograf, Model 3S, is a two-axis graphic recorder designed for general laboratory use. It employs standard 8 1/2" x 11" graph paper and provides two modes of operation. In the normal mode it plots a variable as a function of another variable. A built in time base feature provides a second mode in which the recorder plots functions of time. Five different sweep rates on the X (10") axis may be selected from the front panel. Each axis is controlled by an independent self-balancing servomechanism. In response to DC electrical data applied to the two axes the pen traces in ink a cartesian coordinate graph of the relationship between the input signals. When operated in the time mode, it plots the relationship between a signal applied to the Y axis and time.

The input circuit and servo system comprising each axis are shown in the block diagram below.



BLOCK DIAGRAM

FIG. 2

The basic voltage range of the servo systems is 0 to 3.5 millivolts for the Y axis and 0 to 5.0 millivolts for the X axis for full scale travel. Operation with greater input voltages is obtained by means of a step attenuator inserted between the input terminals and the balance circuit. Each range step may be made continuously variable by operation of a transfer switch which inserts a variable potentiometer and extends that range to about five times its fixed value. The range position is selected so that the amplitude of the input data will be within the travel limits of the instrument. Included in the input circuit is a filter which minimizes undesirable noise and ripple disturbances in the input signals.

After passing through the input filter and attenuator, the input signal is applied to a balance circuit where it is cancelled by an internally supplied opposing voltage derived from a reference cell and potentiometer. Under these conditions there is no signal output from the balance circuit and the servo system is at rest. When the input signal changes to a new value it is no longer cancelled in the balance circuit and the unbalance voltage, or error signal, is applied to a chopper where it is converted to 60 cycle form. The AC output of the chopper is amplified and applied to the control winding of a two-phase servo motor. The motor is mechanically coupled to the balance circuit potentiometer and thus changes the balance voltage until it again cancels the new value of input signal. If the input data is constantly changing within the response capabilities of the instrument, this re-balancing action is continuous. Thus, the positions of the balance circuit potentiometers and of the pen and carriage, to which they are coupled, are always directly proportional to the amplitude of the signals at the respective input terminals.

The time base on the X axis operates on the principle that the voltage across a capacitor increases at a uniform rate when the charging current is held to a constant value. When the recorder is used in the time mode, transfer switching converts the X axis to a current regulating circuit in which the charging voltage for a capacitor is supplied from the servo potentiometer, and the charging current of this capacitor is sampled by a resistor in series with the capacitor. The resulting voltage drop across the series resistor is balanced against a constant voltage, and the unbalance voltage is applied to the input of the servo amplifier in a direction which causes the servo potentiometer to be driven to a position of increased voltage. Now, since the potentiometer is linear, and it supplies the charging voltage for the capacitor, and it is driven in response to variations from a constant charging current of the capacitor, its wiper progresses at a constant rate across the resistance card and thus the pen is driven at a constant rate across the graph paper in the X direction. In the actual circuit, different combinations of capacitors and series resistors are selected to produce the five sweep ranges.

B. SPECIFICATIONS

1. MECHANICAL DATA

Case Form: Sheet aluminum case, chassis fitted with rubber feet for bench or desk top use.

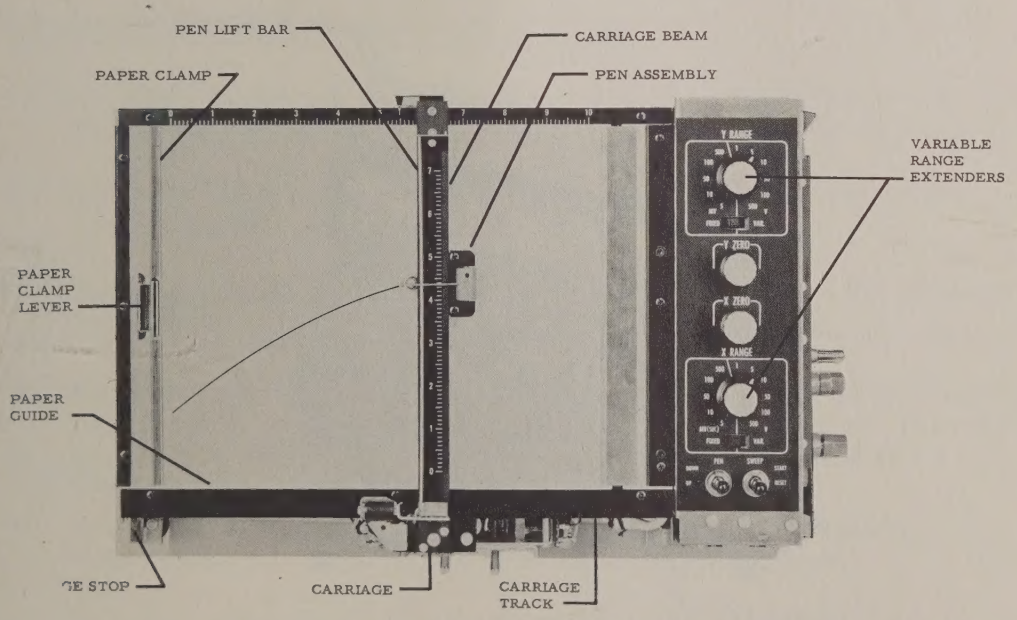
Dimensions: 17" X 11" X 6"

Weight: Approximately 25 pounds

Controls: All operating controls are mounted on a sloping panel at the right of the recording surface. Servo gain controls are located in the window at the front of the case next to the power and servo switches. These controls are operated by knurled knobs projecting through slots in the window. Calibration controls are adjacent to the input terminals.

a. Power Switch

The left-hand toggle switch in the window at the front of the case applies power to the instrument, energizing all components except the servos.



AUTOGRAF TOP VIEW

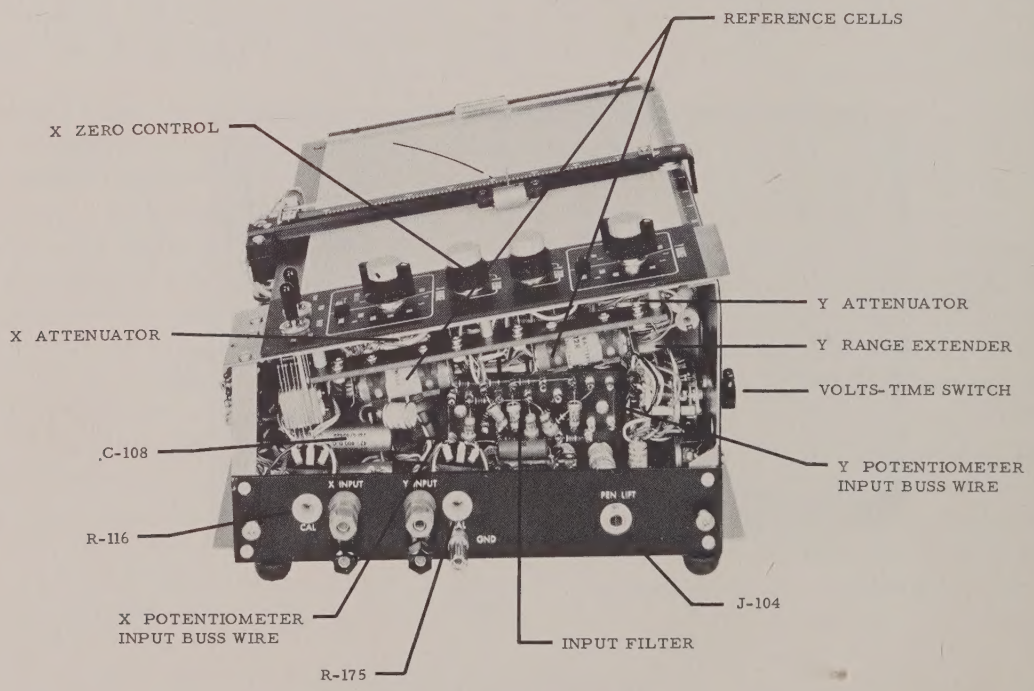
FIG. 3

b. Servo Switch

The right-hand toggle switch in the window at the front of the case energizes the servos by applying power to the fixed phase windings of the two drive motors and to the excitation windings of the choppers. With this switch in the down position the recorder is in a standby condition and the pen and carriage may be moved by hand.

c. Scale Range Controls

The scale range controls are located on the control panel. Both stepped and continuously variable controls are provided. The scale positions represent input voltages required to drive the X or Y axes to full scale. The volts/inch calibration of each axis is identical on corresponding fixed selector ranges, hence an input voltage of 0.7 times the selector setting will be sufficient to drive the Y axis to full scale. Below each selector knob is a slide switch for selection of either fixed or variable range. With this switch in the "VAR" position the maximum voltage acceptance of any range setting can be continuously extended to about five times its indicated value by adjustment of the potentiometer knob projecting through the center of the range selector knob.



AUTOGRAF SIDE VIEW

FIG. 4

SUPPLEMENT FOR MODEL 5 AUTOGRAF RECORDER

(For use with Model 3 Instruction Manual)

A. General Description

The Autograf, Model 5, is essentially a Model 3 Autograf designed for rack mount and hence oriented with its recording surface in a vertical plane. This supplement, with the Model 3 Manual, will serve as an Instruction Manual for the Model 5.

The chassis and recording table assemblies are essentially the same as on the Model 3. The rack case is mounted separately to the rack, and the chassis is attached to the case with four screws at the edges of the front panel. The front panel is equipped with carrying handles.

A light contact spring ensures positive pen contact with the paper in the "down"position, and also holds the pen firmly against its upper pivot.

B. Relocation of Input Terminals and Controls

a. The input terminals are located on the front cover, below the recording surface.

b. The power and servo switches are located at the bottom of the control panel.

c. The gain controls are located behind the nameplate door between the input terminals.

d. The filter switch, damping controls, and straps for potentiometer-type input are located on a panel on the right side of the chassis, accessible when the chassis is tilted from its rack case.

e. The calibrating rheostats are located below the side panel, accessible by tilting the chassis out of the rack case.

f. The fuse is accessible from the rear of the chassis.

C. Maintenance

a. For access to the side panel controls, calibrating rheostats, and calibration batteries, the chassis must be tilted out of its rack case. To do this, remove the four screws attaching the front panel to the rack case. Then use the handles to pull the chassis out to its stop, and allow the top to tilt forward to its stop.

b. For access to chassis components, the chassis must be removed from the rack case. To do this, remove the four screws attaching the front panel to the rack case. Then pull the chassis out to its stop, depress the latch levers through holes on each side of the chassis at the lower right and left edges, and pull chassis straight out of rack case.

c. In order to remove the recording table from the chassis for restringing or potentiometer replacement, the front panel must be taken off by removing the four corner screws after the chassis has been taken out of the rack case.

This feature can be used to permit convenient fitting of experimental data to any portion of the graph. Input voltage should never exceed 500 volts, however. The volts/inch calibration of the instrument as determined by the position of these controls does not change with the setting of the zero control.

Obviously any Y range may be adjusted with this extender so that the voltage read from the range selector setting will drive the Y axis to actual full scale (7 instead of 10) if desired.

d. Zero Controls

The zero controls are located on the front panel and consist of dual, single turn, concentric shaft potentiometers, providing a "coarse-fine" zero adjustment. By use of these controls zero may be placed anywhere on the graph paper or suppressed up to one full scale length in either or both axes. Therefore, through proper adjustment of the zero controls, data may be plotted in any desired quadrant.

NOTE: To prevent strain on the servo drives, the zero scale offset should be employed only to counteract a steady-state input which drives the graph toward full scale, or to re-position the minimum point at scale zero. It should not be used to establish the minimum point effectively off the paper, causing the servo drives to exert continuous force against the stop mechanisms.

e. Pen Lift Switch

The pen lift switch is located at the bottom of the control panel. In the "Down" position this switch applies voltage to an electromagnet which releases a lever system normally holding the pen off of the paper. Thus, with power removed from the instrument the pen will always be in a non-writing position.

f. Time Interval Actuator Switch

When the time base feature is used, initiation of a chosen sweep action is accomplished by the toggle switch located to the right of the pen lift switch. Movement of this switch to the "Start" position causes the sweep to begin. The pen is automatically lowered to the paper during this operation. The "RESET" position causes the pen to return to the zero position on the paper, and raises the pen preparatory to making a new sweep.

g. Input Filters

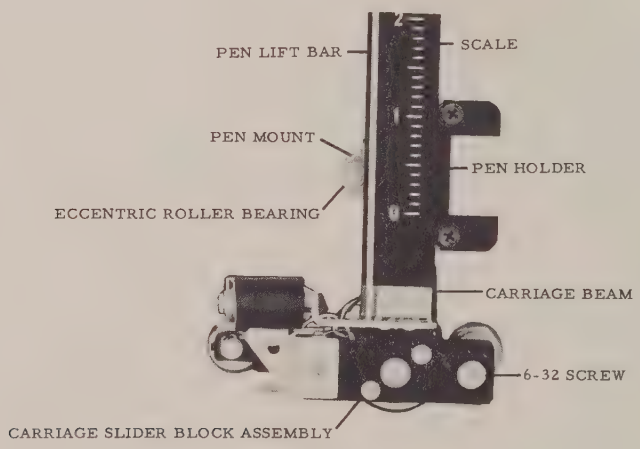
The input circuit of each axis contains a low pass filter which provides about 26 db attenuation at 60 cycles and rapid cut-off at higher frequencies. Without impairing recorder performance this filter eliminates many forms of undesireable noise often found in laboratory set-ups.

h. Fuse

A 2 amp, 250 volt fuse is located in a fuse holder accessible from underneath the Autograf.

PAPER REQUIREMENTS: Recording is done on standard 8 1/2" x 11" graph paper, the scales on the machine being accurately aligned with Dietzgen 340-5, 5 x 5 to the inch, or Moseley 10070A, 10 x 10 to the inch.

Pen Assembly: The pen assembly consists of a drum type reservoir resting in a pivot mount which moves along the carriage beam. A rigid capillary tube feed line leads from the reservoir to the pen point. The pen is raised from the paper by a lever system which is opposed by an electromagnet to lower the pen to the paper. The pen mount extends underneath the carriage beam and houses a wiper for the balance potentiometer.



PEN ASSEMBLY

FIG. 5

Carriage Assembly: The carriage base is an inverted U-beam with tracks on either side for the pen mount rollers, and pulleys at each end for the pen cable. A spring loaded, roller mounted, "T-square" type carriage is cable driven along a track at the front of the recording table. A pulley at the bottom of the carriage track mount is driven through a drafting machine type drive from the pen servo, and is splined to the front pen cable pulley. The bottom of the carriage beam houses the slidewire potentiometer for the pen servo balance circuit, and the inside of the carriage track mount houses a wiper for the carriage servo balance potentiometer. This latter slidewire is mounted adjacent to the track at the front of the recording table.

2. ELECTRICAL DATA

Power Requirements: 115 volts, 60 cycles, single phase, approximately 75 volt amperes. Special models operating from 200 volts and/or 50 cycles are available on special order. IMPORTANT: For optimum performance it is essential that the third prong in the AC power plug be grounded.

Vacuum Tubes: Standard RETMA vacuum tubes are used as follows:

2	12AX7 Twin Triodes
2	6AN8 Triode-pentodes
4	12AB5 Beam Power Triodes

Input Data Signals: The Autograf input terminals must be supplied with DC signals which are linear (or other desired) functions of the original information. These signals must vary at a rate within the response capabilities of the instrument and have amplitudes within its scale ranges. CAUTION: Input voltages in excess of 500 volts should not be applied to the recorder. The variable range extender is designed to increase the versatility of the instrument, not its maximum voltage range.

Input Connections: Input terminals for both X and Y axes are located on the right side of the instrument. In operations where minimum current drain is required, the recorder may be used as a self-balancing potentiometer. To convert to this type of operation, remove the potentiometer input buss wires located on the input circuit board. (See Fig. 4) Under these conditions the input voltages by-pass the input attenuator and the full sensitivity of the instrument is utilized. When used in this manner the source resistance should be 1500 ohms, or less, and the amplifier gain may have to be increased to reduce the servo dead zone. Full scale deflection will be obtained with inputs of 5.0 millivolts and 3.5 millivolts on the X and Y axes, respectively. It should be noted that when the recorder is operated in the potentiometer mode the servos will not null without a load connected to the input terminals.

Grounding: Near the input terminals is a fifth binding post which provides a common grounding point for connection with the apparatus under test.

3. PERFORMANCE DATA

Voltage Ranges and Sensitivity: Each axis of the Model 3S Autograf provides 11 voltage ranges. In addition, the "fixed-variable" selector switch and potentiometer can be used to continuously extend the maximum voltage acceptance of each range about five times. The fixed ranges are 0 to 5, 10, 50, 100, and 500 millivolts; 0 to 1, 5, 10, 50, 100, and 500 volts. (On the fixed Y axis ranges, 0.7 times the selector setting will give full scale deflection). Sensitivity is 200,000 ohms per volt for each axis on fixed ranges

from 5.0 mv to 10.0 volts, and is lower on the three higher ranges to maintain reasonable impedance levels. If the variable range extender is used, sensitivity is decreased only if the input voltage actually exceeds the fixed range setting. Sensitivity and impedances for all fixed ranges are as follows:

Range	Sensitivity (ohms/volt)	Full Scale current drain (micro-amperes)	Input resistance (ohms)
5 mv	200,000	5	1,000
10 mv	200,000	5	2,000
50 mv	200,000	5	10,000
100 mv	200,000	5	20,000
500 mv	200,000	5	100,000
1 v	200,000	5	200,000
5 v	200,000	5	1,000,000
10 v	200,000	5	2,000,000
50 v	40,000	25	2,000,000
100 v	20,000	50	2,000,000
500 v	4,000	250	2,000,000

Accuracy and Resolution: As shipped from the factory, the Autograf has an initial accuracy of 0.20% of full scale on all ranges. Resolution is within this figure.

Response Speeds: Both axes have identical response, requiring a maximum of 1/2 second for full scale travel. The pen traverses the 8 1/2" side of the paper; the carriage moves along the 11" side.

Damping Characteristics: The Model 3S is shipped from the factory adjusted for critical damping. However, proper gain setting is necessary to produce optimum performance. Gain adjustment is discussed in the Maintenance Section.

Calibration Stability: Short term calibration drift of the Autograf is negligible. Long term calibration change due to aging of the reference batteries will accrue at the rate of about 0.25% each 6 months. During the 12 to 18 months expected life of the batteries this drift can be compensated for by recalibrating the recorder when maximum accuracy is required. Calibration procedure is described in the Maintenance Section.

SECTION II - OPERATION

A. OPERATION AS A STANDARD X-Y RECORDER

For satisfactory operation of the Autograf the phenomena to be recorded must:

a. Be reduced to direct current, the available voltage being a linear or other desired function of the original information.

b. Have amplitudes within the scale ranges of the recorder (5 millivolts to 500 volts).

c. Vary at a rate within the response capabilities of the instrument.

Assuming the above signal conditions to be met, the Autograf may be placed in operation as follows:

1. Connect the power cord to a 115 volt, 60 cycle power source and turn the unit on by moving the left hand toggle switch to the "UP" position. The pilot light will indicate that power is applied.

2. Place ink in the pen reservoir. This is done with the small injector supplied in the accessory kit. Do not completely fill the reservoir, and use Esterline-Angus recording ink only. The rubber bulb may be applied to the filler hole to force ink through to the tip.

3. Load paper as follows:

   a. Place pen lift switch in "UP" position.

   b. Turn servo switch "OFF" (down position).

   c. Push the carriage by hand to approximately the middle of the paper.

   d. Slide paper under the carriage onto the paper bed.

   e. Lift paper clamp bar (at left end of table) with the left hand and insert paper under the paper clamps with the right hand.

   f. Position paper against stops at bottom and left hand edge. Release clamp.

4. Connect the X and Y components of the data to be recorded to the X and Y input terminals, and set the scale range switches to the expected maximum values. Place function selector switch in "VOLTS" position.

5. With the pen lifted from the paper, move the right hand toggle switch to the "UP" position to energize the two servos. The input data can now be "dry" run through its range and its position on the paper set by adjusting the zero controls as desired. Now lower the pen and run the data through its range to produce the record.

6. The right hand, servo-energizing, toggle switch applies power to the fixed phase windings of the two drive motors and to the exitation windings of the choppers. This switch should be placed in the "OFF" position whenever the recorder is not actually making curves, thereby lowering the power dissipation and avoiding unnecessary wear of the balance potentiometers and other parts.

7. Whenever voltages in excess of the scale range setting are applied to the input terminals, the servo will drive quickly to one end of travel and strike the drive mechanism stop. These stops have been provided to protect the balancing potentiometers from damage. The recorder should not be allowed to strain against the stops for long periods.

B. OPERATION WITH TIME BASE

1. Place function selector switch in "TIME" position.

2. Prepare recorder and load paper as described in A.

3. Connect data to Y input and set Y range switch to expected maximum.

4. Select desired time sweep on X range switch, (one of the first five positions, calibrated in seconds).

5. With pen lift switch in "UP" position turn on servo switch. Now adjust zero controls to position pen at desired point on the paper.

6. To initiate sweep, place time switch in the "START" position. The pen will be automatically lowered to the paper. To make "dry" runs, remove the pen from its holder.

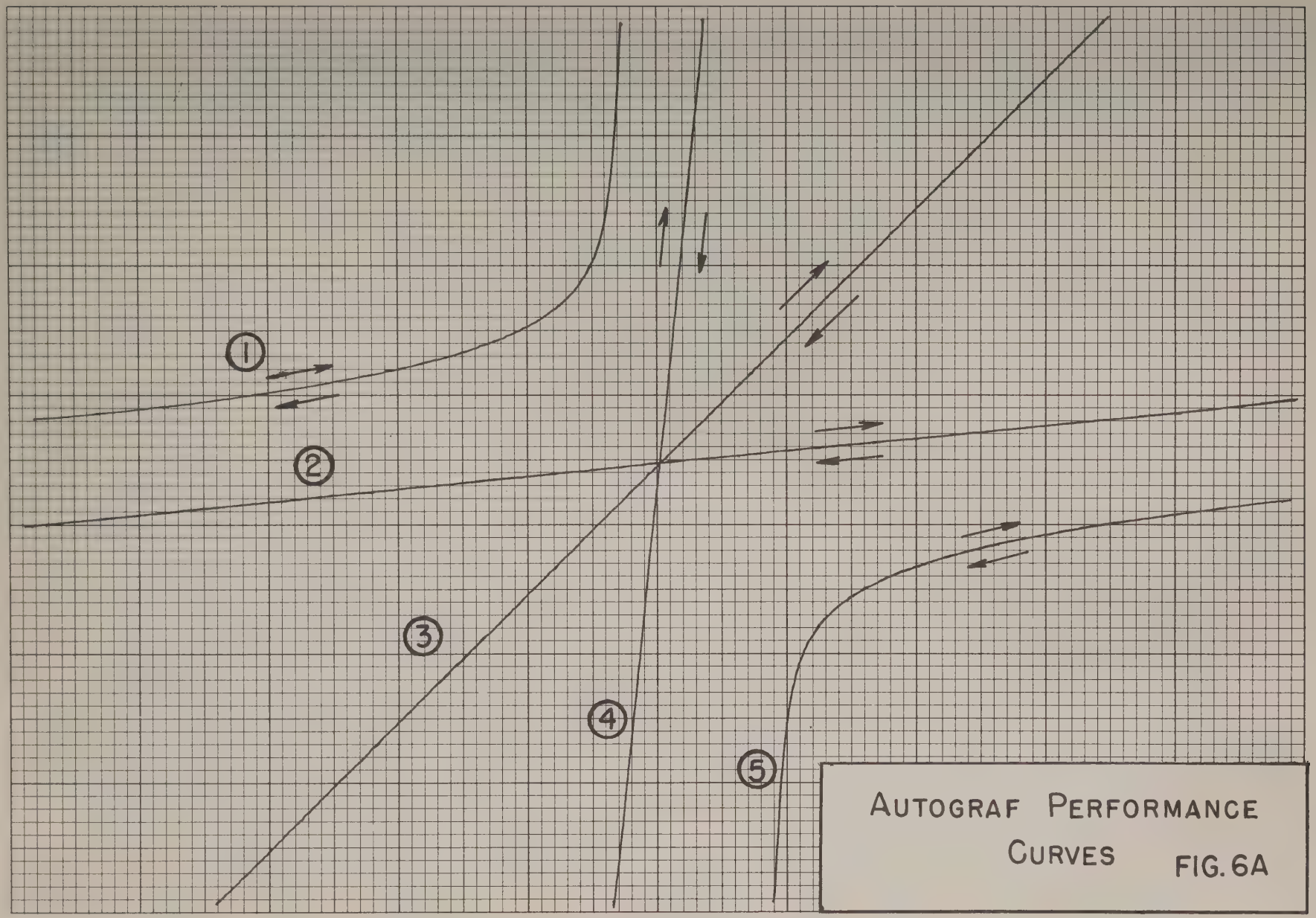
C. TYPICAL RECORDING PERFORMANCE

Figs. 6A, 6B, and 6C show actual recorder performance. These curves were drawn on a normal production recorder using Moseley 10070A paper.

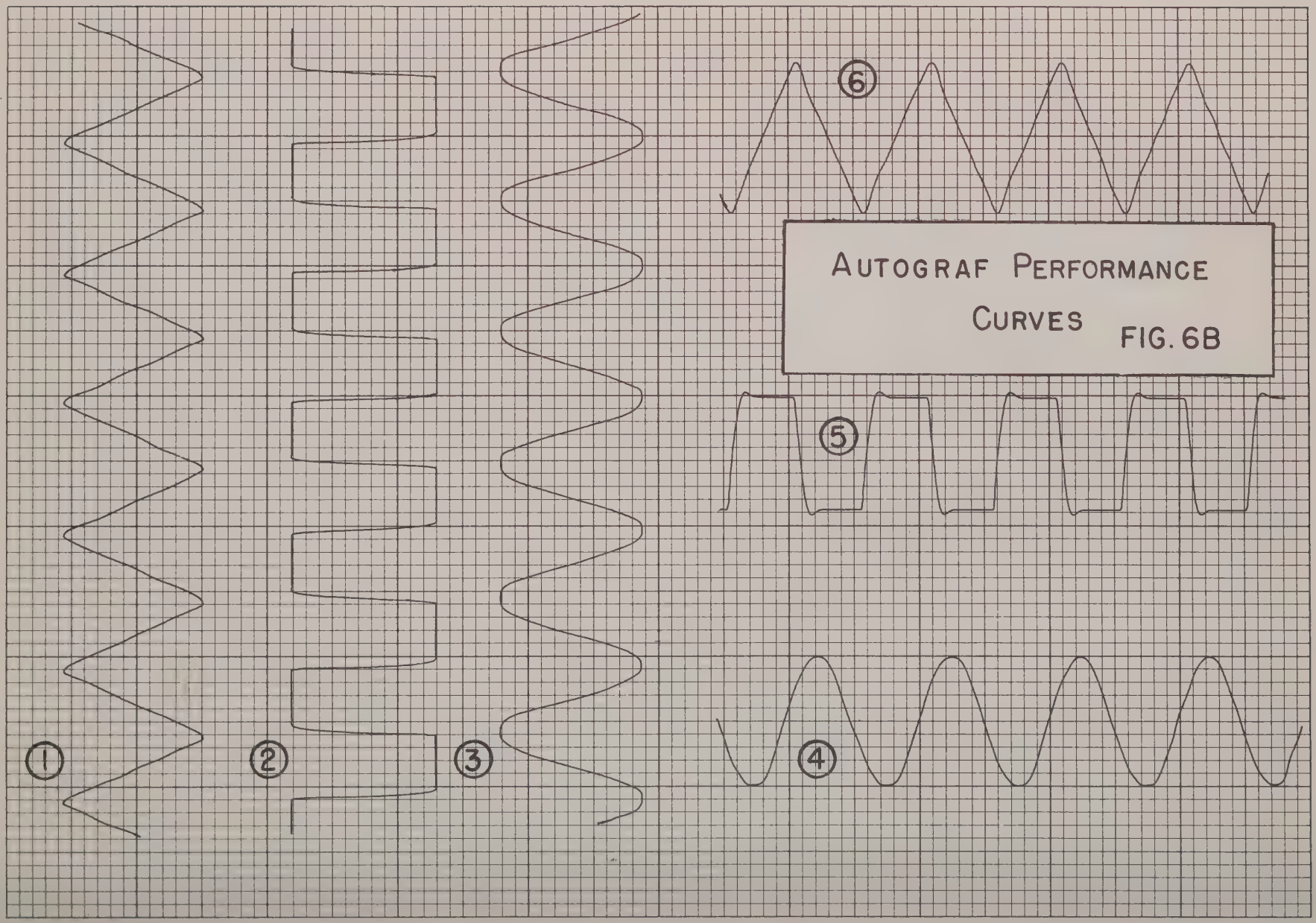
Curves of Fig. 6A show straight lines and curves drawn from a hand operated signal source, similar to the test rig of Fig. 8. Curved records were produced by recording current vs. voltage of a type 1N34 diode. All recordings of Fig. 6A show original "trace" and "re-trace". This clearly illustrates any servo dead zone or lag.

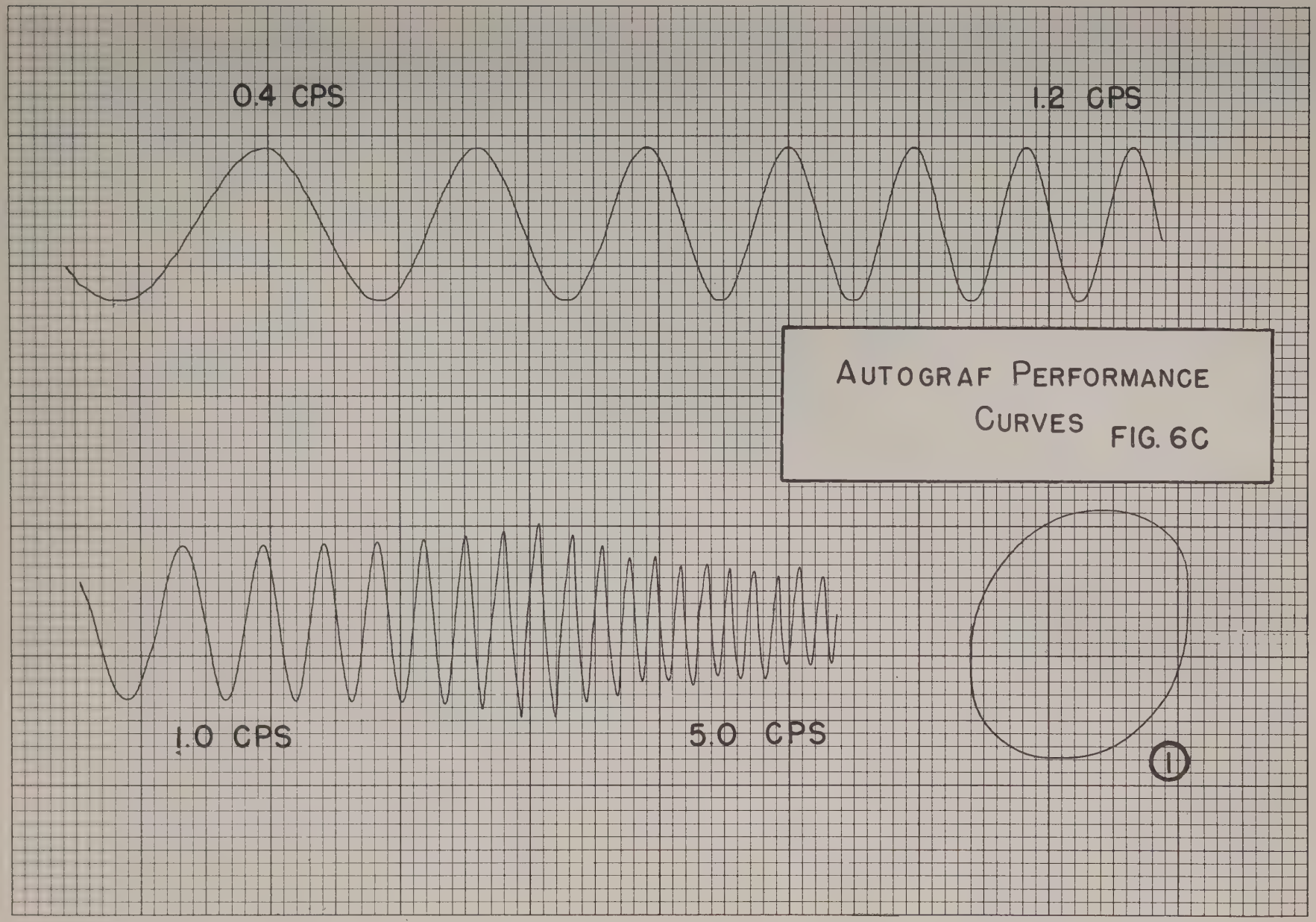
Fig. 6B shows sine, triangular, and square waves plotted against time.

Fig. 6C shows a sine wave recorded from a variable frequency oscillator. This demonstrates the speed and following characteristics of the recorder. Fig. 6C (1) shows an elipse recorded using sine wave input with phase difference between the two axes. The input was derived from a Moseley servo tester. The pen was allowed to re-trace its path to indicate any dead zone.



AUTOGRAF PERFORMANCE CURVES FIG. 6A


AUTOGRAF PERFORMANCE
CURVES FIG. 6B
1
2
3
4
5
6


0.4 CPS
1.2 CPS
AUTOGRAF PERFORMANCE CURVES FIG. 6C
1.0 CPS
5.0 CPS
1

SECTION III -- CIRCUIT DESCRIPTION

It is the purpose of this section to describe the Model 3S Autograf recorder in detail. Reference should be made to the circuit schematic as required.

A. INPUT ATTENUATOR

Each pair of input terminals connects to a precision step attenuator which determines the voltage range. The Autograf input attenuator is composed of 10 precision (0.1%) wirewound resistors. The precision resistors making up the attenuators may be seen in Fig. 4. With the selector switch in the 3.5 or 5 mv position the input voltage is applied across 1000 ohms, and goes directly to the balance circuit without attenuation. The balance voltage is always 3.5 and 5 mv full scale for the Y and X axes respectively. Thus, to obtain higher input voltage ranges, resistance is inserted in series with the 1000 ohms. Above the 10 volt scale, changes are made by shunting the 1000 ohms, and no more series resistance is added to the string.

For maximum sensitivity, the Model 3S Autograf may be used as a self-balancing potentiometer by removing the buss wires shown in Fig. 4 thus disconnecting the input attenuators from the circuit. S-106 and S-104, the "fixed-variable" switches on the control panel, route input voltages through the variable extender potentiometers R-112 and R-153 which are in series with R-113 and R-151 respectively, to limit the maximum voltage acceptance multiplication for each axis to about 5.

B. INPUT FILTER (C-103, C-104, C-106, R-125, R-126 and R-127 in X; and C-110, C-111, C-113, R-162, R-163 and R-164 in Y)

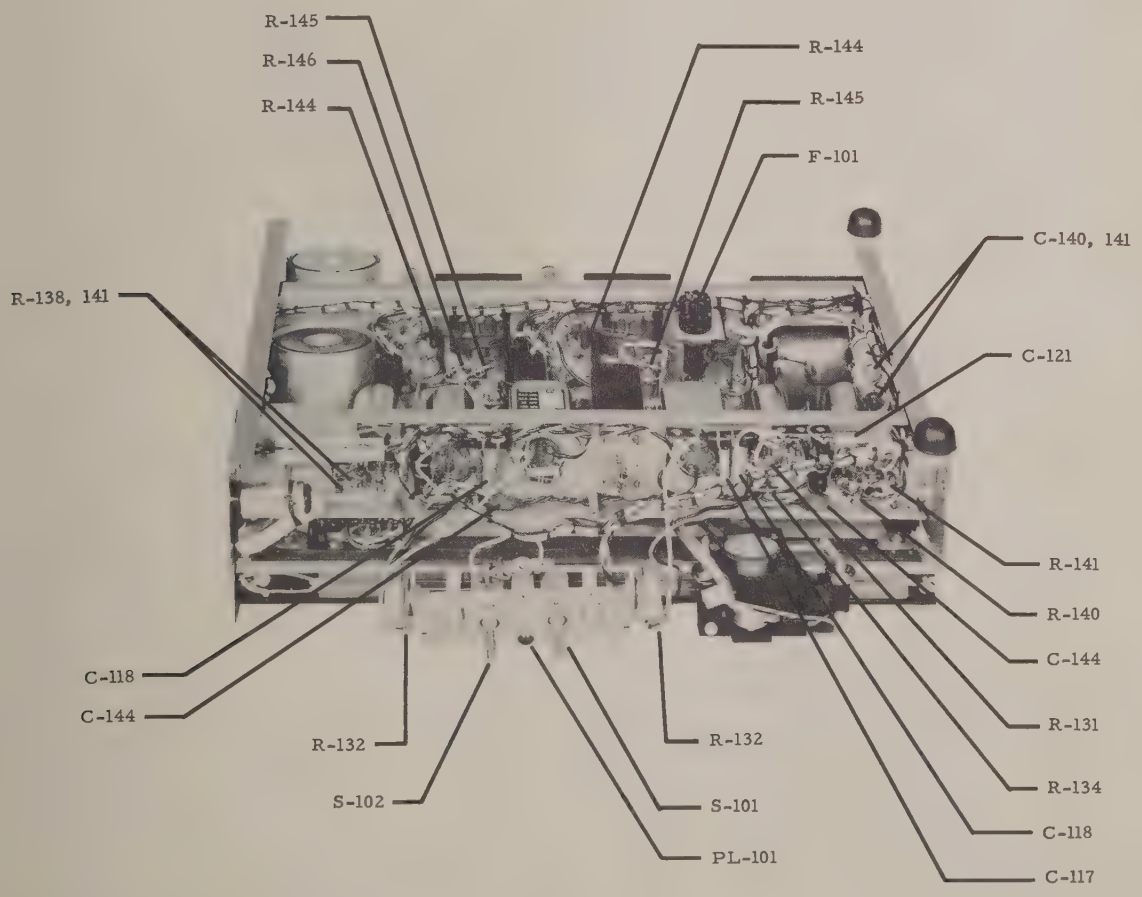
The above listed components comprise an input filter in each axis of the recorder. This is a low pass filter providing about 26 db attenuation at 60 cycles and rapid cut-off at higher frequencies. It eliminates many forms of undesireable noise found in laboratory setups without impairing the performance of the recorder.

C. BALANCE CIRCUIT

Cancellation voltage for balance is obtained from the mercury cells B-101 and B-102. Rheostats R-116 and R-175, respectively, are connected in series with these cells to permit adjustment of voltage for purposes of calibration. Relay K-101 disconnects the cells from the circuit to conserve their life when the power switch is off. Potentiometers R-115 and R-174, respectively, are the X and Y axis zero setting controls. Potentiometers R-117 and R-172 are the balance potentiometers. The cancellation potential appears across R-122 in X and across R-169 in Y.

It will be noticed that the values of the resistors R-117, R-119 and R-120 are 5K, 68K, and 170K respectively in the X axis balance circuit, whereas the corresponding resistors in the Y axis circuit are 3.5K, 100K, and 238K, respectively. This is necessary to equalize the sensitivity of the two channels in terms of millivolts per inch of travel.

The choice of resistance values in the balance circuit is governed by the requirements that the potentiometers must impose little drain on the reference cells, yet be low in value compared to R-120 (in the X channel) and R-171 (in the Y channel) so that potentiometer loading and the resulting nonlinearity will be held within the accuracy limits of the instrument. In addition, the DC attenuation provided by R-122 and R-169 serves the beneficial purpose of reducing potentiometer noise. This noise is predominately the result of two effects: imperfect contact of the wiper on the resistance element which results in a saw-tooth component of noise voltage, and a triboelectric DC voltage which is generated by friction of dissimilar metals.



AMPLIFIER FRONT VIEW

FIG. 7

D. CHOPPER AND INPUT TRANSFORMER

The DC difference between the input signal and the rebalance voltage (error signal) is converted to 60 cps AC by the chopper. As the chopper is driven in synchronism with the power line, the AC error signal output from the transformer will be either (disregarding the chopper lag) in phase or 180 degrees out with respect to the line, depending on the polarity of the DC error signal. The direction of rotation of the servo motor is determined by the relative phasing of excitation of its two windings, and this phase-sensing causes the motor to drive the potentiometer R-117 or R-172 in the proper direction to seek balance.

A voltage gain of about 13 is realized in the transformer T-101. The total magnitude of error signal never exceeds 3.5 or 5 mv, and as the instrument must be sensitive to approximately 0.1% of this voltage, it is obvious that the error signals being dealt with are exceedingly small, of the order of microvolts. Accordingly, all input circuitry is carefully designed and laid out to minimize interference from stray hum pickup and thermal EMF'S.

E. FIRST AND SECOND VOLTAGE AMPLIFIER STAGES (V-101)

The two triode sections of this tube are connected in cascade as conventional voltage amplifiers. As the first stage operates at extremely low signal levels it is sometimes necessary to select tubes for low hum and microphonics. R-132 on the second stage serves as gain control. The cathode bias condenser is eliminated on the second stage, precluding any undesirable delay in surge amplification due to transient effects.

F. DAMPING (C-101, 142 and R-196 or C-116, 143 and R-197)

Condensers C-101 or C-116 draw a charging current whenever a change in input occurs, increasing the rate of appearance of balance voltage across R-122 or R-169. This phase advance in the slowly varying error signal causes an "anticipatory" approach to the balance point, producing damping. C-142 and R-196 or C-143 and R-197 permit the servo response curve to be shaped further, stabilizing the trace characteristics of the recorder.

G. PHASE INVERTER - AMPLIFIER (V - 102, Type 6AN8)

This combination of triode and pentode serves as a phase inverter and high-gain amplifier, and permits addition of negative feedback. Negative feedback is added through the cathode bias resistor, R-137. The cathode bias condenser is eliminated on the triode element of this stage to preclude any undesirable delay in surge amplification due to transient effects. This precaution is not needed on the pentode due to the constant-current action of this tube.

H. POWER AMPLIFIER (V-103 and V- 104 - Type 12AB5)

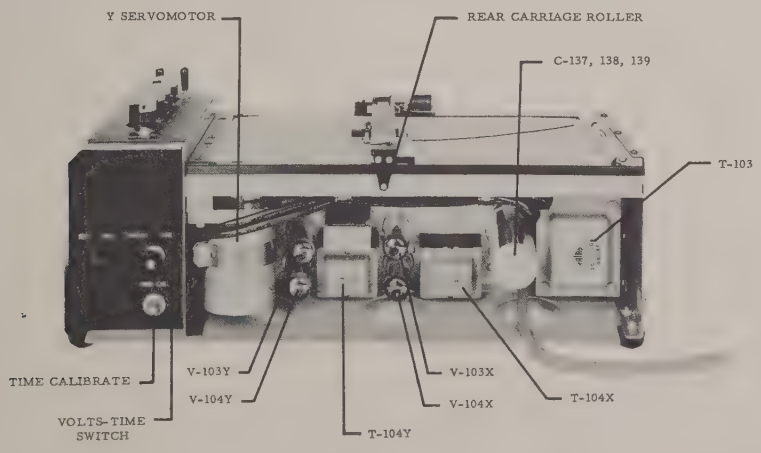
The power output stage is a push-pull tetrode power amplifier. A small amount of degeneration is incorporated to lower the output impedance of the amplifier, and thus prevent the motor from running "single phase", as it otherwise will if one winding is open-circuited while the other is energized. The required feedback is obtained from the divider R-146 and R-145 at the output transformer for introduction to the phase inverter stage. Condenser C-126 serves to resonate the transformer primary. Cathode bias for the power amplifiers is obtained from resistor R-144.

I. POWER SUPPLY

A full wave rectifier circuit (RE-104) provides plate voltage for both amplifier channels. Power for the output stages is supplied directly from the rectifier while the low level stages receive plate potential filtered by R-194 and 195 and C-137, 138 and 139. Switch S-101 is the main power switch, which also energizes the choppers. S-102, the servo on-off control, applies 115 volt, 60 cps power to the fixed phase windings of the two drive motors, and energizes the choppers. S-107 de-energizes the pen lift solenoid K-102, which is provided with rectified AC by RE-101.

J. MOTOR - POTENTIOMETER

The servo motor is a Diehl 5-watt, 2-phase induction motor, one phase of which is energized from the AC line, the other being excited in phase quadrature from the amplifier output. Direction of motor rotation is determined by whether a leading or lagging 90° relationship exists. A pinion on the motor shaft meshes with a large fiber reduction gear which in turn is geared to a sheave which operates the pen or carriage by means of cables, translating angular displacement of the shaft into linear motion of the pen or carriage.



AUTOGRAF BACK VIEW

FIG. 8

K. TIME BASE CIRCUIT

The basic principles of the time base are related on page 6 of this manual. Using the existing facilities of the X-axis high gain chopper input servo system and the addition of minor circuitry, those conditions are accomplished as follows: (refer to schematic)

The voltage drop across R-205 (or R-206) is balanced against the drop taken from a section of the time control potentiometer, R-207, R-208, or R-209, depending on the interval range selected. The difference voltage is applied to the X-axis servo amplifier through the chopper input causing movement of the variable arm of the slide wire potentiometer R-117 in a direction tending to equalize the voltages between the control potentiometer (R-205) and the charging resistor (R-207). Thus, any up-scale movement of R-117 increases the charging voltage applied to the charging condenser C-201 through R-205, increasing the charging current which varies the voltage drop in a direction tending to cancel the fixed voltage supplied from R-207.

Resetting and starting of the time interval action is controlled by S-120. With this switch closed the amplifier input is connected to the slider arm of R-205, R-206 and the slider arm of R-115. The system then operates until R-115 and R-207 are in balance. Opening S-120 starts the timing action. R-120, R-196, C-142 and C-203 provide an error-rate damping network for the input to the servo amplifier.

A. ELECTRICAL MAINTENANCE

1. CALIBRATION, VOLTAGE INPUT

The Autograf Model 3S as shipped from the factory is standardized against a Weston Standard Cell. Based on expected shelf life of the Mercury cell, the calibration should accumulate error at the rate of about 0.25% every six months. The Mercury reference cell may be considered at the end of its useful life in approximately 18 months.

If necessary, the instrument may be calibrated as follows:

a. For maximum accuracy (0.1% or better):

1. Move the power and servo switches to the "ON" position and allow the various components of the instrument to reach a stabilizing temperature.

2. Adjust the recorder zero controls to bring the pen and carriage indices to exactly full scale, ("7" on the Y axis and "10" on the X axis).

3. Set the X and Y scale ranges to the 1.0 volt position; the "var-fixed" switch levers should be in the "fixed" position.

4. Connect an accurately established source of voltage (as obtained, for example, from an L and N precision potentiometer and Weston Standard Cell) with reversed polarity to the recorder input terminals. Connected in this manner, the source voltage will drive the pen and carriage close to the lower left-hand corner of the paper.

5. Adjust the calibrating rheostats (located adjacent to the positive input terminals) to bring the pen and carriage indices into exact agreement with the "0" mark on the X and Y scales. Remove input and check to see if pen and carriage move back to initial position. Repeat adjustments if necessary.

b. For moderate accuracy (0.25%

1. Follow steps 1, 2 and 3 as above.

2. Connect a Weston or other standard cell to the recorder input terminals, with reversed polarity, using an appropriate, accurate series resistor for full scale reading. Correct series resistor values are as follows for the Weston cell:

   For X axis calibration, 1 volt full scale: 2,968 ohms
   For Y axis calibration, 0.7 volt full scale: 90,279 ohms

   These figures take into account the internal resistance of the cell (750 ohms at 68° for 20° C).

3. Now adjust the calibrating rheostats to bring the recorder reading to the "0" mark on the X and Y scales.

c. For rough accuracy (1%)

1. Follow steps 1, 2, and 3 as above.

2. Connect a fresh Mallory Mercury cell (such as those used in the Autograf, Mallory type RM12) to the recorder input terminals through an appropriate series resistor. The correct value of series resistor to be used with a Mallory #RM12 cell (1.345 V) is:

   For X axis calibration, 1 volt full scale: 69, 000 ohms
   For Y axis calibration, 0.7 volts full scale: 184,300 ohms

3. Proceed as in step 3 of b.

d. In the event the recorder cannot be calibrated within the adjusting range of these controls, the Mallory mercury cells should be replaced. These cells are Mallory #RM12, whhch may be obtained from drug stores or electronic supply houses where they are generally stocked for use as replacements in electronic hearing aids.

e. Calibration battery replacement. (See Fig. 4)

1. Remove instrument case.

2. Remove old cells from clips beneath the control panel.

3. After insuring that clips are clean, insert new cells by placing "plus" end of cell toward red clip. Be sure cells are held firmly in place for low contact resistance.

2. CALIBRATION, TIME BASE

Sweep circuit timing is dependent on the basic circuit constants including the reference cell stability. These constants are established during manufacture and normally will not change in use. Reference cell failure will of course affect the voltage calibration as well as the time calibration. For sweep periods of 50 seconds or over, a rough check of timing accuracy may be made with a stop watch. For shorter sweep periods an accurate timing function should be generated on the Y axis for comparison to the actual X axis pen advance. Time corrections may be made by means of a screwdriver adjustment on the rear panel.

When it is desired to vary the full scale sweep time slightly to accomodate a particular operation, the variable feature on the X range control may be used. This method will not disturb the basic calibration.

3. GAIN ADJUSTMENTS

Gain controls are adjusted at the factory for normal applications; they may be re-adjusted for each axis as follows:

a. Set the gain controls to a minimum position by rotating projecting knurled knobs downward.

b. Advance gain control upward for one axis until the recorder hunts.

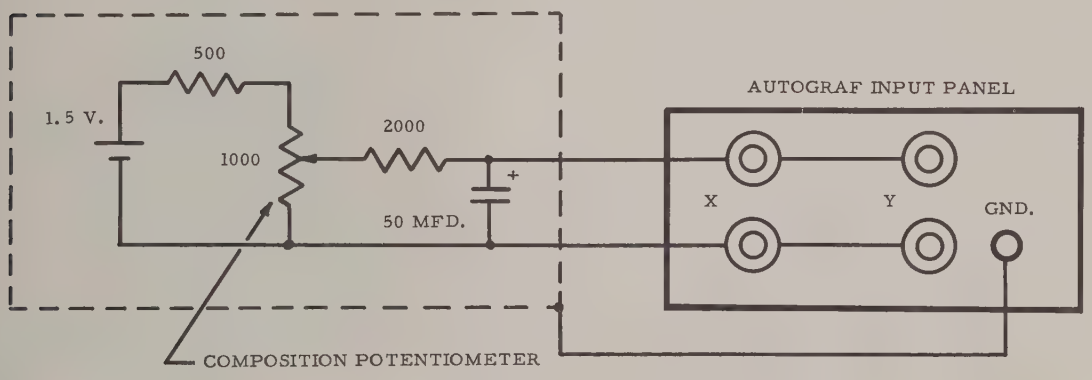
c. Turn gain control downward until hunting action stops.

d. Check the servo for proper operation by rotating the zero control. If response is not snappy and precise, gain was reduced too much.

e. Generally an optimum setting of the gain controls will be found to produce essentially zero retrace when a test signal is introduced into the recorder to draw a record over and back on the same line.

4. PERFORMANCE CHECKING

The simplest method of checking the Autograf is to apply a smoothly varying voltage to both pairs of input terminals and observe the record which is produced. For this purpose a simple test rig is a convenience and one may be made up as shown in Fig. 9.



PERFORMANCE TEST RIG

FIG. 9

When signals from the test rig are fed to the recorder, records should result as illustrated in Fig. 10. Note that these curves are drawn on a "trace" and "re-trace" basis; that is, the curve is drawn up and back over the same line. This procedure shows the servo dead zone and permits gain adjustments to be made for optimum performance.

Gain limits are usually fixed by the following factors:

a. Gain too low:

Servo dead zone, resulting in excessive re-trace or space between the "up" trace and the "down" trace.

b. Gain too high:

Recorder jitters or oscillates.

PERFORMANCE TROUBLE SHOOTING CHART

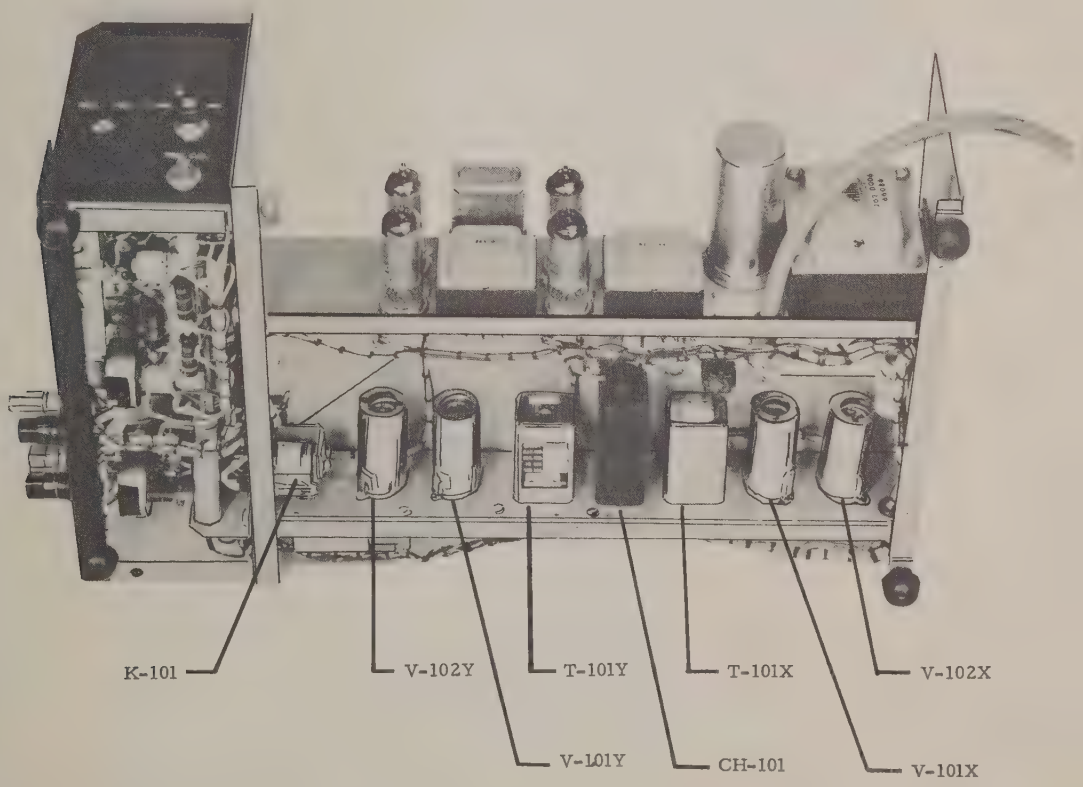
(Made with test rig, Fig. 9)

Incorrect		Correct
	X set on 1 Volt range Y set on 5 Volt range Potentiometer of tester rocked back and forth Insufficient gain in Y channel results in poor retrace. (settings to check X channel: X=5 Volts; Y=1 Volt)	
	Settings as above Rough writing - symptom of too much gain in Y channel	
	Settings as above Roughness in one part of trace probably due to worn or dirty balance pot.	
	Settings as above 3 cyclic variations in trace indicate gear train mesh too tightly adjusted.	
	Connect 1 1/2 V battery to Y input. Leave X input open. Slowly rotate centering (zero) control while rapidly flipping Y attenuator knob between its 5 and 10 volt position. Excessive overshoot and oscillation indicates too much gain in Y channel.	

FIG. 10

Fig. 10 shows a group of records illustrating typical troubles which may be encountered and their probable cause.

A recorder which is performing properly will have a low "stand-by" voltage supplying each of its servo motors. This may be verified by placing an AC voltmeter across terminals 4 and 5 of the output transformers for the pen and carriage motors in turn. These are accessible by removing the bottom cover of the chassis. A stand-by voltage of 5 to 10 volts is normal. If the servo is coerced from its resting position by manually rotating its drive sheave, the stand-by voltage will rise rapidly to a maximum of about 80 volts. A useful check of recorder linearity may be made by connecting the output of the test rig to both axes of the recorder simultaneously. If suitable signals are chosen to produce a line extending entirely across the paper, essentially from corner to corner, the straightness of this line will be a good indication of potentiometer linearity. If both the pen and carriage potentiometers are perfectly linear and both servo systems are "tight", a smooth straight line will be drawn.



AMPLIFIER REAR VIEW

FIG. 11

B. MECHANICAL ADJUSTMENTS

1. AUTOGRAF DISASSEMBLY

Access to the various components of the Autograf may be obtained as follows:

a. Disconnect AC power cable.

b. Loosen (2) shouldered screws on left and right sides of case.

c. Lift case up and off.

d. Bottom cover may be removed by removing its (6) attaching screws, for access to components. Tubes and calibration cells are now accessible.

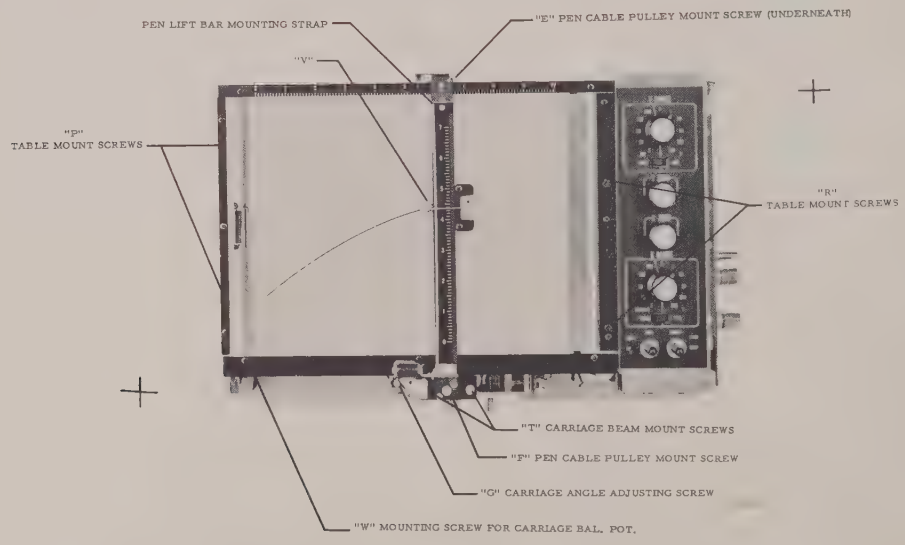
2. REMOVAL OF RECORDING TABLE (See Fig. 12)

a. Lift pen (drum-type ink reservoir) out of pivot mounting.

b. Remove (2) 8-32 Phillips screws from the left end of the recording table and (2) 10-32 Allen cap screws from the right face edge of the recording table.

c. Disconnect motor cable plug under upper left edge; also potentiometer cable plug and pen relay wire under lower right edge of recording table.

d. Lift recording table from chassis.


PEN LIFT BAR MOUNTING STRAP
"E" PEN CABLE PULLEY MOUNT SCREW (UNDERNEATH)
"V"
"P"
TABLE MOUNT SCREWS
"R"
TABLE MOUNT SCREWS
"T" CARRIAGE BEAM MOUNT SCREWS
"F" PEN CABLE PULLEY MOUNT SCREW
"G" CARRIAGE ANGLE ADJUSTING SCREW
"W" MOUNTING SCREW FOR CARRIAGE BAL. POT.

AUTOGRAF TOP VIEW

FIG. 12

3. REMOVAL AND ADJUSTMENT OF CARRIAGE BEAM (see Fig. 12)

a. To remove carriage beam from carriage track mount, lift pen from pivot mounting and remove (2) 8-32 Phillips screws from top of "T-square" mount. NOTE: With cables still connected to pot and relay, carriage beam has only limited area of movement.

b. When re-installing, check mating of spline with pulley at "T" end.

c. To adjust "T-square" angle of carriage beam loosen set screw and turn eccentric screw (G) on top of left roller mounting spindle, and retighten set screw.

d. Adjustment of Pen Mount: Contact between the pen mount rollers and their tracks can be adjusted by loosening the mounting screw of the roller on the pen tip side and adjusting its eccentric mounting stud with a stiff wire inserted into the adjusting hole.

4. ADJUSTMENT OF GEAR MESH

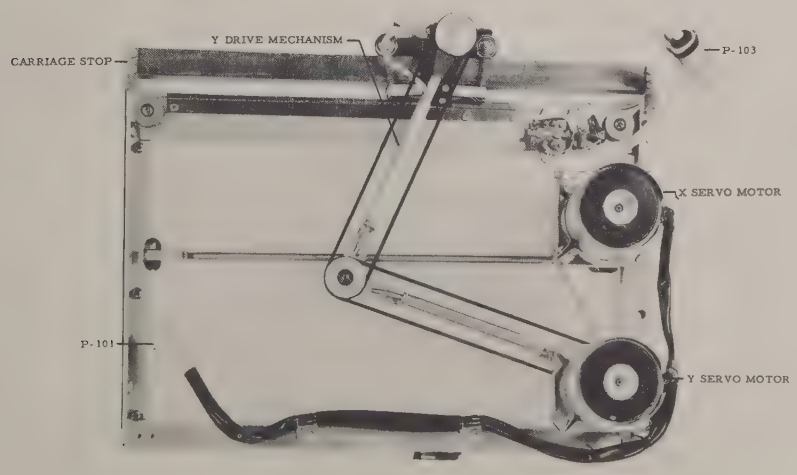
Back lash of the gear drive system may be adjusted as follows (with recording table removed):

a. Loosen 3 servo motor housing clamp screws (Fig. 13).

b. Rotation of motor housing will move motor pinion into or out of close mesh with fiber gear of cable drive sheave, due to eccentric mounting of motor housing.

c. Rotate motor slightly first in one direction then in the other, meanwhile rapidly rocking drive sheave back and forth to feel for ease of rotation and detectable backlash.

d. After proper backlash has been obtained by adjustment, retighten 3 motor housing clamp screws.



RECORDING TABLE BOTTOM VIEW

FIG. 13

5. POTENTIOMETER REPLACEMENT

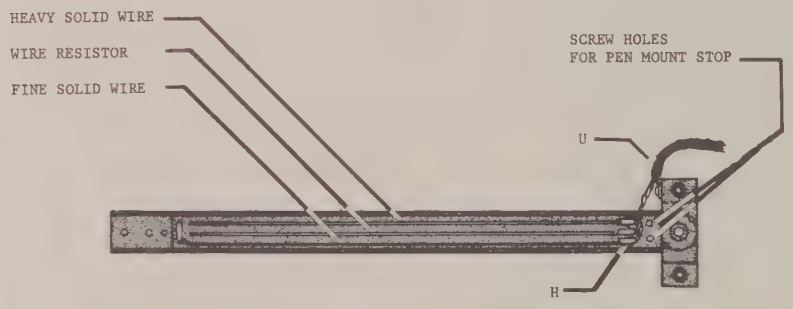
Remarks were made under "Performance Checking" regarding the testing of potentiometer linearity by application of a smooth test voltage simultaneously to both axes. If this test indicates non-linearity, one or both potentiometers must be replaced. Potentiometer assemblies including the rebalance potentiometer and its mount (the front edge of the table frame with the X axis pot; the carriage beam with the Y axis pot) are available from the factory.

a. Replacement of pen balance pot (in carriage beam) (See Fig. 12 and 14)

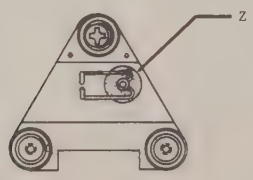
1. Remove carriage beam, and remove pen lift bar by removing its mounting straps.

2. Loosen Phillips screw (V) on single roller side of pen mount, and with stiff wire or tool rotate stud of this roller about its eccentric axis enough to permit all rollers to clear track.

3. Turn carriage beam sideways and remove mounting screws (E) and (F) of both pen mount cable pulleys.



CARRIAGE BEAM, BOTTOM VIEW
SHOWING PEN BALANCE POTENTIOMETER



PEN MOUNT, BOTTOM VIEW

Y AXIS BALANCE POTENTIOMETER AND WIPER

FIG. 14

4. Lift pen mount and cable assembly away from under side of beam, taking care not to let cable kink.

5. Remove triangular pen mount stop covering terminal strip (H).

6. Unsolder (3) wires from the pot at (H) and remove.

7. Disconnect cable mounting lug (U).

8. Insert wires in new pot and solder; White lead to heavy solid wire; red lead to center resistance wire; green lead to fine solid wire.

9. Attach cable mounting lug and pen mount stop on new carriage beam.

10. Re-install pen mount and cable assembly and tighten pulley mounting screws (E) and (F). Avoid side movement perpendicular to wire axes to prevent wiper damage to wires.

11. Set eccentric stud on pen mount roller for free running along track with minimum "play", and tighten screw (V).

12. Check to see that wiper makes even contact with slide wires.

13. Install pen lift bar and scale assembly from old beam.

b. Replacement of carriage balance pot (at lower front edge of recording table) (See Fig. 15)

1. Remove recording table and carriage beam and turn table over.

2. Remove track mount wiper by loosening set screw (X).

3. Remove springs (K) between track mount rollers.

4. Remove screws (J) connecting roller mount arms to track mount, and remove roller arms.

5. Pull track mount straight out from face of slide wires.

6. Unsolder ground wire from lug (L) and white wire from terminal (M).

7. Unscrew lug (L) and replace it on new pot assembly.

8. Unsolder ground wires from lug (P) and white wires from terminals (O) and (N). Put an identification tape on wire to (O).

9. Unscrew lug (P) and replace it on new pot assembly.

10. Remove (3) screws (W) holding pot flange to table.

11. Pull pot assembly away from table.

12. Attach new pot assembly to table with screws (W), and solder wires to their proper terminals on the pot.

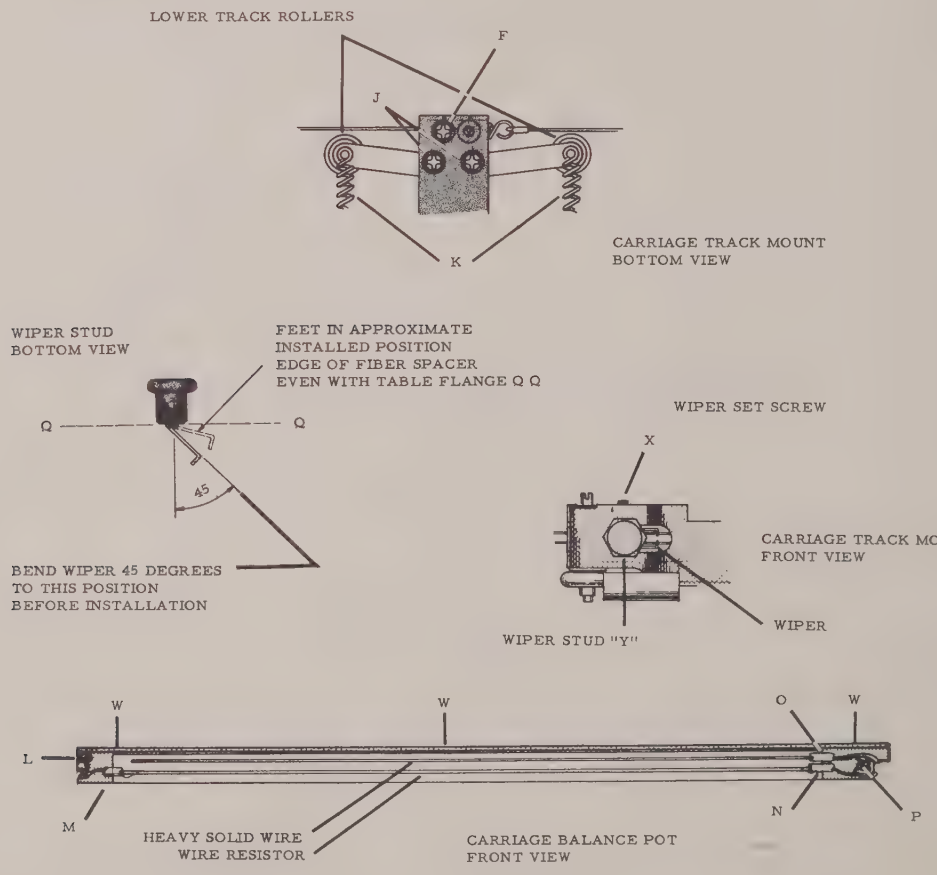
13. Re-install all wires and ground leads. Note wire identified in (8).

14. Place track mount against track and re-install roller mount arms and roller springs.

15. Bend wiper carefully out to about 45 degrees from extended axis of stud.

16. Locate wiper pointing to right and centered on the wires, using screw slot (Y) in wiper stud for adjustment. Push wiper against slide wires for firm contact, until fiber spacer between wiper and stud is even with front edge of recording table flange. Then tighten set screw (X).

17. Replace carriage beam.



X AXIS BALANCE POTENTIOMETER AND WIPER

FIG. 15

6. PEN MAINTENANCE

After the pen has been lifted out of its mounting, the tip may be cleaned by soaking in alcohol. (If alcohol does not dissolve the dried ink clean tip with fine wire or apply pressure through ink system with syringe inserted in reservoir filler hole).

7. LUBRICATION

a. No lubrication of mechanical parts is required. The motor and gear train are lubricated at the factory and do not require lubrication in service.

b. Do not oil roller tracks. Oil leakage onto adjacent resistance elements may cause poor wiper contact.

8. SLIDE WIRE MAINTENANCE

Irregular or "jumpy" plots produced by smooth input signals on a properly adjusted recorder may indicate a worn or dirty slide wire potentiometer. The resistance wire mandrel may be cleaned with a moderately stiff brush using gentle strokes at right angles to its length, (parallel to the individual turns of fine wire). Great care should be taken to prevent damage during this operation.

The silver slider bar may be cleaned with a lintless cloth moistened slightly with a solvent which will not leave a greasy residue.

The sliding contact should be adjusted as shown in Fig. 15, page 32. Correct contact pressure is approximately 15 grams.

9. RESTRINGING INSTRUCTIONS

Three independent cable and sheave assemblies are used in the driving mechanism of the pen and carriage. One of the cable assemblies utilizes a seven-strand stainless steel cable 1/64" in diameter. This cable should be handled carefully to avoid kinks. The "drafting machine" type drive uses 2 slightly elastic fabric cables. The pen (Y) axis uses a prestretched nylon cord. (NOTE: Models prior to Ser. No. 1123 used the steel cable described above).

In each case the cable should be only tight enough to prevent lost motion. Excessive tension may cause "retrace" trouble. The stringing is very simply done if the following instructions are followed:

a. Pen Axis:

i. Pen mount drive cable. (nylon) See Fig. 16

1. Remove carriage beam and turn over to expose pulleys.

2. Be careful not to damage slide wire potentiometer under carriage beam.

3. Unhook spring and hook from pen carriage plate and discard.

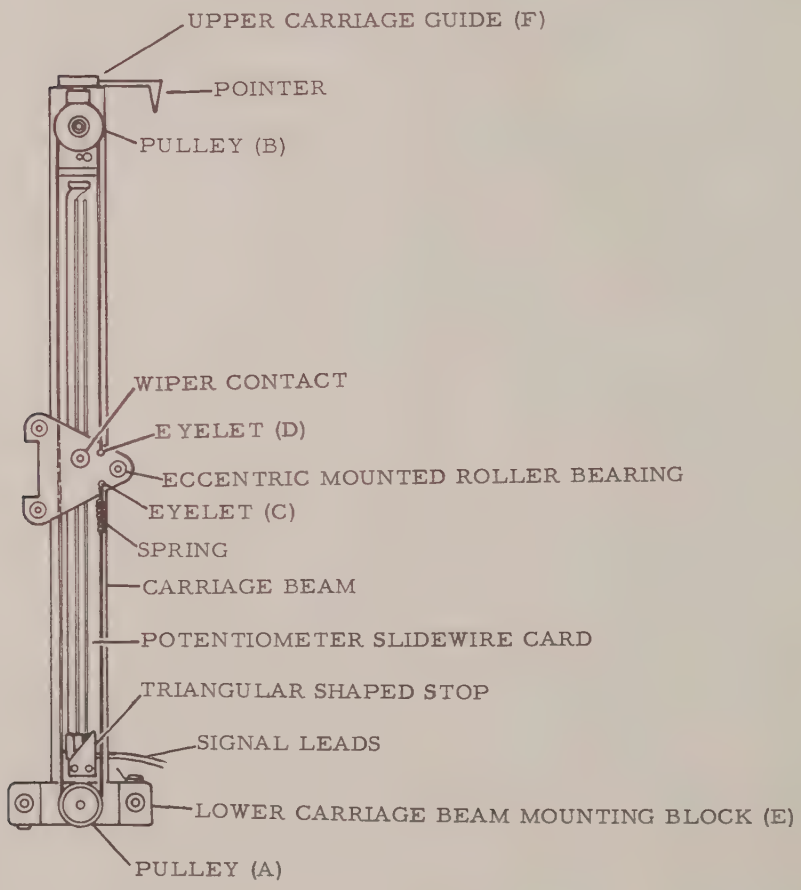
4. Place hook of new cable assembly in hole next to contact on carriage plate as shown in Fig. 16.

5. Carry cable around pulley and pass underneath pen carriage plate.

6. Hook spring in remaining hole and snap cable over other pulley.

7. Make sure springs are in holes designated in Fig. 16.

8. Replace arm on slider block.



PEN MOUNT DRIVE CABLE

FIG. 16

ii. Fabric dental belts from carriage block to servo motor block (Fig. 17).

1. Remove recording table to expose underside.

2. Replacement of belt from pulley (B) to (C) is obvious.

3. To remove belt from pulley (B) to "Y" axis motor block (A) proceed as follows:

   a. Remove "Y" axis motor block (G) by removing the two holding screws.

   b. Remove retaining ring and pantograph arm (D) from motor block.

   c. Remove old belt and replace with new one.

   d. Replace pantograph arm, retaining ring, and motor block.

b. Carriage axis cable (steel) (Fig. 18)

1. Remove screw (F) holding carriage drive pin to slider block assembly.

2. Remove old cable.

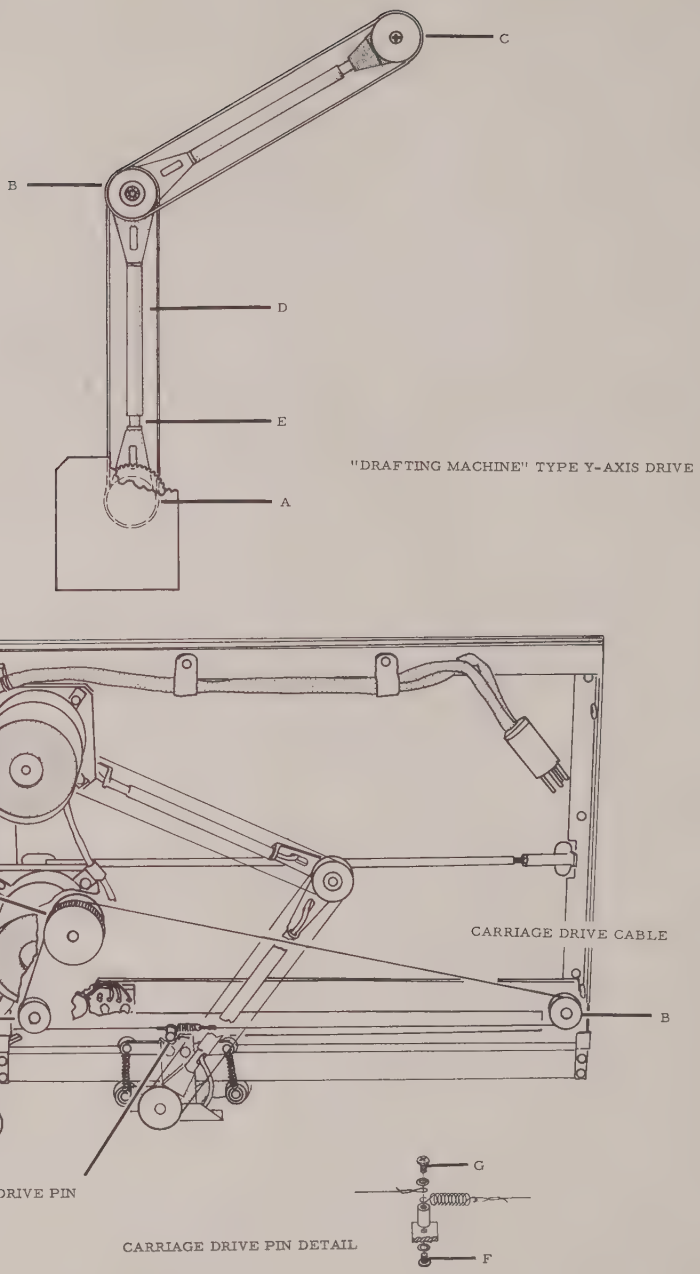
3. Fasten spring and loop on one end of cable to drive pin with screw (G).

4. Replace drive pin on slider block assembly.

5. Run cable CW around pulley (B), CW two and one-quarter turns around motor drive sheave (A), and CW around pulley (C).

6. Run cable through crimp fitting, loop through spring, back through crimp fitting, and pull tight.

7. Flatten crimp and cut off excess cable.



RESTRINGING DIAGRAM--CARRIAGE DRIVE CABLE

FIG. 18

C. TROUBLE SHOOTING

The following difficulties, other than malfunctioning caused by improper adjustment, may be encountered:

TROUBLE	POSSIBLE CAUSE
Dead zone, manifested by inability to obtain acceptable retrace.	1. Weak 12AB5 tubes in amplifier.
	2. Loss of voltage gain in amplifier due to weak 12AX7 or 6AN8 tubes, or component failures.
	3. Friction in mechanical linkage.
	4. Weak regerence cell.
	5. Backlash adjustment incorrect.
Noisy, or rough trace.	1. Microphonic 12AX7; Weak 6AN8
	2. Worn or noisy potentiometer. (if roughness usually appears at same portion of scale)
	3. Input filter not functioning.
	4. Instrument not grounded.
	5. Poor reference cell relay contact.
	6. Loose signal cable shield connection.
	7. Poor reference cell contact.
	8. Insufficient contact pressure or improper positioning of wiper on slide wire balance potentiometer (s).
Interaction between axes.	1. Unbalanced output tubes (12AB5).
	2. Chopper malfunctioning.
Machine inoperative after replacement of reference battery. Pen hits stops.	1. Reference cells inserted with wrong polarity.
	2. Poor contact to reference cells.
Pen lowering circuit fails to operate.	1. Open pen coil.
Sweep velocity decreases and appears non-linear.	1. Low servo gain.
	2. Mechanical binding.

TROUBLE	POSSIBLE CAUSE
Sweep velocity decreases.	1. Weak Y reference cell.
Sweep velocity increases.	1. Weak X reference cell.
Sweep inoperative.	1. "VOLTS-TIME" switch in "VOLTS" position.
Noisy or rough sweep.	1. Worn or dirty potentiometer.
Sweep Reverses.	1. Operating with X-range switch in other than time sweep position. 2. One sweep capacitor open.

SECTION V - ACCESSORY EQUIPMENT

While the Autograf, Model 3S, has many direct uses in its standard form, its utility may be increased by the addition of accessory equipment available for specialized applications. In some cases factory installation is necessary. Some will operate with the Model 3S without modification. For the user's information a partial list of the available accessories follows:

A. TYPE F-1 CURVE FOLLOWER

Makes possible the read-out of curves prepared by applying a conducting ink to the original tracing. Requires factory modification of standard recorder by installation of Cannon receptacle, RF pickup coil (to replace pen), and contact clips for connection to conducting curve.

B. POINT PLOTTER ACCESSORIES

Permits the recorder to be connected directly to Model 40 Keyboard series, or Model 42 Digital Data Translator for plotting from digital data stored in perforated paper tape or punched cards. Requires factory modification.

C. MODEL 60B LOGARITHMIC CONVERTER

Transforms AC or DC signal voltages to recorder input voltages proportional to the logarithm of the original voltages for direct semi-log plotting. Log-log plotting is obtainable by using two converters. Requires no recorder modification.

D. TYPE A-1 AC TO DC CONVERTER

A two-channel device which supplies a DC voltage proportional to the positive peak amplitude of the AC input signal for application to either or both axes of the recorder. Frequency response of the converter is 20 cps to 100 KC. Requires no recorder modification.

WARRANTY

F. L. Moseley Co. warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year after delivery to the original purchaser. Liability under this warranty is limited to servicing, adjusting, or the replacement of defective parts, (other than tubes, fuses or batteries) on any machine returned to the factory for this purpose, transportation charges prepaid. Before returning to the factory for any reason notify us of the difficulty encountered, the model and serial number of the instrument and we will furnish you service or shipping instructions.

F. L. Moseley Co.
409 North Fair Oaks Avenue
Pasadena, California

SECTION VI

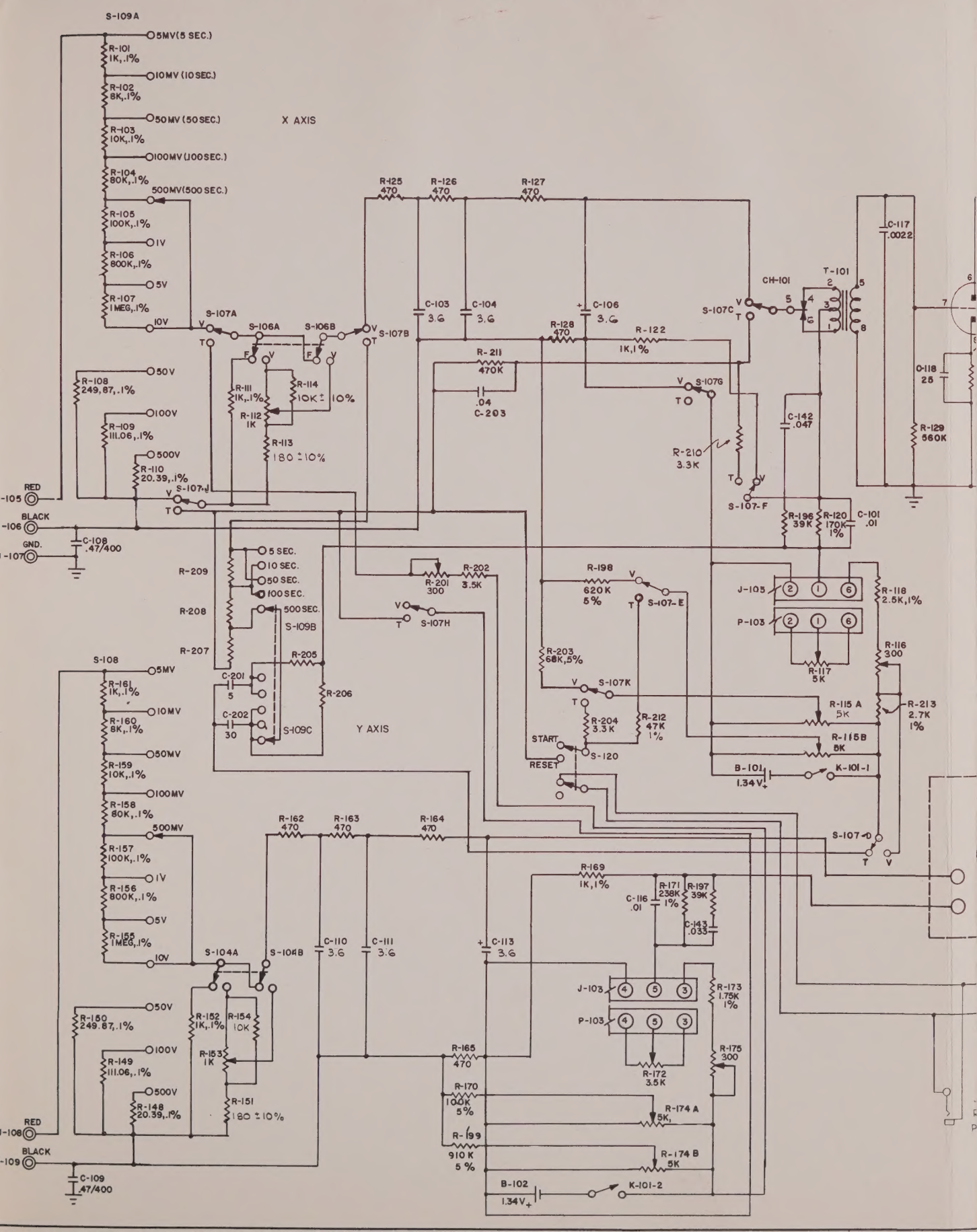
PARTS LIST - MODEL 3S AUTOGRAF

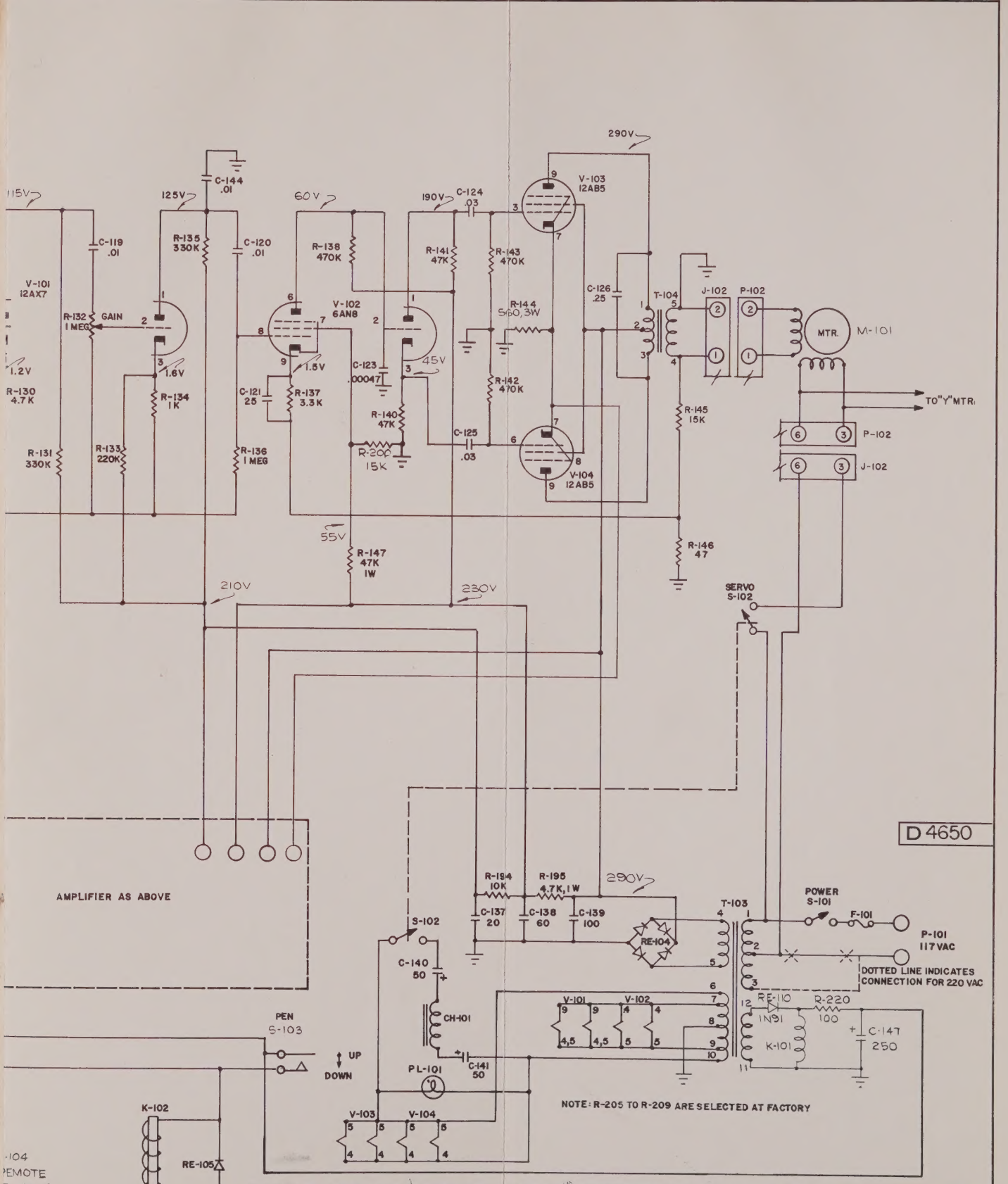
Circuit Symbol	Moseley Part No.	Part Description	Mfr./Mfrs. Designation
B-101	329-0001	Battery; mercury 1.34V	Mallory RM-12
B-102		Same as B-101	
C-101	233-0016	Capacitor; paper .01 MFD, 400 VDCW	Sprague 67P10304
C-103	235-0008	Capacitor; tantalum 3.6 MFD, 60 VDC	Fansteel F-115
C-104		Same as C-103	
C-106		Same as C-103	
C-108	233-0008	Capacitor; paper .47 MFD, 400 VDCW	Sprague 78P47404S5
C-109		Same as C-108	
C-110		Same as C-103	
C-111		Same as C-103	
C-113		Same as C-103	
C-116		Same as C-101	
C-117	233-0019	Capacitor; paper .0022 MFD, 100 VDC	C-D Miniroc STM 1D22
C-118	231-0020	Capacitor; electrolytic 25 MFD, 3 VDC	Sprague TE 1055
C-119		Same as C-101	
C-120		Same as C-101	
C-121	231-0020	Capacitor; electrolytic 25 MFD, 3 VDC	Sprague TE 1055
C-123	230-0005	Capacitor; mica 470 MMFD, 1000 VDC	Centralab DD-471
C-124	233-0024	Capacitor; paper .03 MFD, 400 VDC	Sprague 4 TM
C-125		Same as C-124	
C-126	233-0044	Capacitor; paper Dual .25 MFD, 600 VDC	Gudeman B-823
C-137	231-0007	Capacitor; electrolytic(3 section) 20 MFD, 250 VDC	Mallory FP-335
C-138		Section of C-137 60 MFD, 250 VDC	
C-139		Section of C-137 100 MFD, 300 VDC	
C-140	231-0006	Capacitor; electrolytic 50 MFD, 25 VDC	Sprague TVA 1206
C-141		Same as C-140	
C-142	233-0020	Capacitor; paper .047 MFD, 400 VDC	Sprague 67P47304
C-143		Same as C-124	
C-144	238-0007	Capacitor; ceramic .01 MFD, 600 VDC	ERIE Type 811
C-147	231-0009	Capacitor; electrolytic 250 MFD, 50 VDC	Sprague TVA-1312
C-201	235-0003	Capacitor; tantalum 5 MFD, 50 VDC	Fansteel PP5B5OA1
C-202	235-0007	Capacitor; tantalum 30 MFD, 6 V	Fansteel PP30B6A1
C-203	234-0002	Capacitor; .04 MFD, 200 VDC	Aerovox Type P83Z
CH-101	221-0007	Converter; mechanical MBB contacts 50/60 CPS	Stevens-Arnold BA-11-11
F-101	331-0053	Fuse; 2 Amp., 250 V.	Buss-AGX-2
J-102	301-0010	Socket; 6 pin	Amphenol 78-S65
J-103		Same as J-102	
J-104	346-0008	Jack; remote pen control	Switchcraft "Little-Jax" 12A
J-105	312-0002	Binding Post: red	Superior DF 30 RC
J-106	312-0003	Binding Post: black	Superior DF 30 BC
J-107	312-0005	Binding Post: ground	General Radio 938A
J-108		Same as J-105	
J-109		Same as J-106	
K-101-1-2	326-0067	Relay, DPST 26.5 VDC	Advance Spec. TH-1005
K-102	A-6010	Solenoid Assembly	Moseley
M-101	227-0004	Motor; servo, x-axis AC low inertia	Diehl FPE25L-156-1
M-102		Same as M-101, y-axis	
P-101	296-0001	Cord Assembly AC Power	Belden
P-102	316-0004	Plug; 6-pin	Amphenol 91MPM6L
P-103		Same as P-102	
PL-101	336-0012	Lamp; pilot Min. Bayonet, 12 volt	Tung-Sol #53
R-101	243-0018	Resistor, precision ww 1000 ohms, .1%	Cinema 410JE
R-102	243-0025	Resistor, precision ww 8000 ohms, .1%	Cinema 410E
R-103	243-0076	Resistor, precision wire wound 10,000 ohms, .1%	Cinema 410E
R-104	243-0027	Resistor, precision wire wound 80,000 ohms, .1%	Cinema 410E
R-105	293-0028	Resistor; precision wire wound 100,000 ohms, .1%	Cinema 410E
R-106	243-0099	Resistor; precision wire wound 800,000 ohms, .1%	Cinema R111JE
R-107	243-0101	Resistor; precision wire wound 1 meg. .1%	Cinema SW1AE
R-108	243-0010	Resistor; precision wire wound 249.87 ohms, .1%	Cinema 410E
R-109	243-0011	Resistor; precision wire wound 111.06 ohms, .1%	Cinema 410JE
R-110	243-0012	Resistor; precision wire wound 20.39 ohms, .1%	Cinema 410JE
R-111		Same as R-101	
R-112	236-0022	Resistor; variable 1000 ohms	Allen-Bradley J-606 97
R-113	241-0032	Resistor; carbon 180 ohms, 5% 1/2 W	Allen-Bradley
R-114	241-0010	Resistor; carbon 10 K ohms, 10%, 1/2 W	Allen-Bradley
R-115	236-0047	Resistor; variable 5 K, Dual	Chicago Tel. L2-252
R-116	236-0046	Resistor; variable 300 ohms	Chicago Tel. 31795
R-117	B-2079	Resistor; slide wire, 5000 ohms	Moseley
R-118	243-0140	Resistor; precision wire wound 2500 ohms, 1%	Cinema B111E
R-120	243-0103	Resistor; precision wire wound 170 K, 1%	Cinema B111E
R-122	243-0014	Resistor; precision wire wound 1000 ohms, 1%	Cinema B111JE
R-125 Through R-128	241-1470	Resistor; carbon 470 ohms, 10%, 1/2 W	Allen-Bradley
R-129	241-0560	Resistor; carbon 560,000 ohms, 10%, 1/2 W	Allen-Bradley
R-130	241-1047	4.7 K ohms, 10%, 1/2 W	Allen-Bradley
R-131	241-0330	Resistor; carbon 330,000 ohms, 10%, 1/2 W	Allen-Bradley
R-132	236-0010	Resistor; variable composition 1 meg	Centralab BA211-1294

Circuit Symbol	Moseley Part No.	Part Description	Mfr./Mfrs. Designation
R-133	241-0220	Resistor; carbon 220,000 ohms, 10%, 1/2 W	Allen-Bradley
R-134	241-0024	Resistor; carbon 1000 ohms, 10%, 1/2 W	Allen-Bradley
R-135		Same as R-131	
R-136	241-2001	Resistor; carbon 1 meg, 10%, 1/2 W	Allen-Bradley
R-137	241-1033	Resistor; carbon 3300 ohms, 10%, 1/2 W	Allen-Bradley
R-138	241-0470	Resistor; carbon 470 K, 10%, 1/2 W	Allen-Bradley
R-140	241-0047	47 K, 10%, 1/2 W	
R-141		Same as R-140	
R-142	241-0470	Resistor; carbon 470,000 ohms, 10%, 1/2 W	Allen-Bradley
R-143		Same as R-142	
R-144	240-0003	Resistor; wire wound 560 ohms, 5%, 3 W	Sprague 151E
R-145	241-0015	Resistor; carbon 15 K, 10%, 1/2 W	Allen-Bradley
R-146	241-0091	Resistor; carbon 47 ohms, 10%, 1/2 W	Allen-Bradley
R-147	241-0055	Resistor; carbon 47 K, 1 W, 10%	Allen-Bradley
R-148		Same as R-110	
R-149		Same as R-109	
R-150		Same as R-108	
R-151		Same as R-113	
R-152		Same as R-111	
R-153		Same as R-112	
R-154		Same as R-114	
R-155		Same as R-107	
R-156		Same as R-106	
R-157		Same as R-105	
R-158		Same as R-104	
R-159		Same as R-103	
R-160		Same as R-102	
R-161		Same as R-101	
R-162 Through R-165		Same as R-125	
R-166		Same as R-124	
R-169		Same as R-122	
R-170	241-0076	Resistor; 100 K 5%, 1/2 W	Allen-Bradley
R-171	243-0102	Resistor; precision wire wound 238,000 ohms 1%	Mepco WM10
R-172	B-1985	Resistor; slide wire 3500 ohms	Moseley
	B-1985A	Potentiometer Assembly Y-axis	Moseley
R-173	242-0041	Resistor; deposited carbon 1750 ohms, 1%, 1/2 W	IRC
R-174		Same as R-115	
R-175		Same as R-116	
R-194	241-0010	Resistor; carbon 10,000 ohms, 10%, 1/2W	Allen-Bradley
R-195	241-0014	Resistor; carbon 4700 ohms, 10%, 1 W	Allen-Bradley
R-196	241-0027	Resistor; carbon 39,000 ohms, 10%, 1/2 W	Allen-Bradley
R-197		Same as R-196	
R-198	241-0093	Resistor; 620 K, 5%, 1/2 W	Allen-Bradley
R-199	241-0094	Resistor; 910 K, 5%, 1/2 W	Allen-Bradley
R-200	241-0074	Resistor; 15 K, 5%, 1/2 W	Allen-Bradley
R-201	236-0046	Potentiometer 300 ohms	Chicago-Tel HR 4025
R-202	243-0239	Resistor; 3.5 K, 1%	Cinema B111E
R-203	241-0092	Resistor; 68 K, 5%, 1/2 W	Allen-Bradley
R-204	241-1033	Resistor; 3.3 K, 10%, 1/2 W	Allen-Bradley
R-205 Through R-209		Factory selected for each instrument	
R-210	241-1033	Resistor; 3.3 K, 10%, 1/2 W	Allen-Bradley
R-211	241-0470	Resistor; 470K, 10%, 1/2 W	Allen-Bradley
R-212	241-0047	Resistor; 47 K, 1%, 1/2 W	Allen-Bradley
R-213	243-0240	Resistor; 2.7 K, 1%, 1/2 W	Cinema SW1AE
RE-104	252-0006	Rectifier; Silicon (4 required)	Sarkes-Tarzian # 40K
RE-105	255-0002	Diode, Selenium	International Rect. IVI
RE-110	252-0005	Diode, Germanium	G.E. IN91
S101	261-0007	Switch; toggle SPST (Power switch)	AH & H 20994
S-102	261-0001	Switch; toggle DPST (servo switch)	AH & H 20902
S-103	261-0002	Switch; toggle SPST (Pen lift)	AH & H 20993
S-104	A-2245	Switch Assembly	Centralab PA-2001
S-106		Same as S-104	
S-107	262-0002	Switch;lever	Switchcraft 3001 L
S-108	C-2024	Selector Switch Assembly	Moseley
S-109	A,B,C	Same as S-108	
S-120	261-0015	Lever Switch	Switchcraft L3006
T-101	204-0002	Transformer; input	Triad, G40144
T-103	202-0006	Transformer; power	Triad, 67447
T-104	204-0006	Transformer; output	Thermador CS-0895
V-101	251-0007	Tube; vacuum 12AX7	RCA Type 12AX7
V-102	251-0017	Tube; vacuum 6 AN8	RCA Type 6 AN8
V-103	251-0016	Tube; vacuum 12 AB5	RCA Type 12 AB5
V-104		Same as V-103	

MISCELLANEOUS ITEMS

318-0019	Curve Follower Adaptor Plug	Cannon WK-5-23C-3/8
B-1322	Curve Follower Pick-up Coil	Moseley
333-0007	Curve Follower Conducting Ink	DuPont "Silver"
A-7856	"Y" Arm Nylon Cable Assembly	Moseley
294-0001	Drive Cable (steel)	MacWyte
209-0001	Belt, Vacuum Pump	S.S. White #104
B-2101	Ink Pen Assembly, Model 3S	Sheldon Mfg. Co.
B-2913	Ink Pen Assembly, Model 5S	Sheldon Mfg. Co.
333-0005	Recording Ink, red	Esterline-Angus
333-0006	Recording Ink, green	Esterline-Angus
333-0009	Syringe	Cent. Sc. 18075
333-0008	Filler Bottle	Walsco #989


S-109A
5MV(5 SEC.)
R-101 1K,.1%
10MV (10 SEC.)
R-102 8K,.1%
50MV (50 SEC.)
R-103 10K,.1%
100MV (100 SEC.)
R-104 80K,.1%
500MV(500 SEC.)
R-105 100K,.1%
1V
R-106 800K,.1%
5V
R-107 1MEG,.1%
10V
X AXIS
S-107A
S-106A
S-106B
S-107B
R-125 470
R-126 470
R-127 470
C-103 3.6
C-104 3.6
C-106 3.6
R-128 470
R-122 1K,1%
R-211 470K
.04 C-203
S-107C
CH-101
T-101
C-117 .0022
C-118 25
R-129 560K
S-107G
R-210 3.3K
C-142 .047
S-107-F
R-196 39K
R-120 170K 1%
C-101 .01
R-108 249,87,.1%
50V
R-109 111.06,.1%
100V
R-110 20.39,.1%
500V
R-111 1K,.1%
R-112 1K
R-113 180 ±10%
R-114 10K ± 10%
S-107-J
RED
J-105
BLACK
P-106
GND.
J-107
C-108 .47/400
R-209
R-208
R-207
5 SEC.
10 SEC.
50 SEC.
100 SEC.
500 SEC.
S-109B
R-201 300
R-202 3.5K
S-107H
R-198 620K 5%
S-107-E
J-103
P-103
R-118 2.5K,1%
R-116 300
R-117 5K
R-203 68K,5%
S-107K
R-115 A 5K
R-213 2.7K 1%
R-115B 5K
R-204 3.3K
R-212 47K 1%
START
RESET
S-120
B-101 1.34V
K-101-1
S-107-D
S-108
5MV
R-161 1K,.1%
10MV
R-160 8K,.1%
50MV
R-159 10K,.1%
100MV
R-158 80K,.1%
500MV
R-157 100K,.1%
1V
R-156 800K,.1%
5V
R-155 1MEG,.1%
10V
C-201 5
C-202 30
S-109C
R-205
R-206
Y AXIS
R-162 470
R-163 470
R-164 470
R-169 1K,1%
C-116 .01
R-171 238K 1%
R-197 39K
C-143 .033
S-104A
S-104B
C-110 3.6
C-111 3.6
C-113 3.6
J-103
P-103
R-173 1.75K 1%
R-172 3.5K
R-175 300
R-165 470
R-170 100K 5%
R-174 A 5K
R-199 910K 5%
R-174 B 5K
B-102 1.34V
K-101-2
R-150 249.87,.1%
50V
R-149 111.06,.1%
100V
R-148 20.39,.1%
500V
R-152 1K,.1%
R-154 10K
R-153 1K
R-151 180 ±10%
RED
J-108
BLACK
J-109
C-109 .47/400



REVISIONS			
A	3-3-59	WHH	REMOVED S-103A & S-103B C-107, C-114 & JUMPER STRAPS FROM INPUT
B	Nov 30, 59	JRC	REMOVED EE-302 ADDED R-238, CHGD R-126 470K WAS 270K, R-247 47K WAS 220K, R-205, 209 WAS 2W
C	Nov 31, 59	JRC	REPOSITIONED C-140, P-101 & T-102
D	1-28-60	JRC	CORRECTED CIRCUIT
E	Feb 24, 60	JRC	REPOSITIONED EQUIP. RELATED CIRCUIT FEEDERS
F	JUN 6-60	JRC	
G	7-6-60	JRC	CORRECTED PEN LIFT CKT FROM T-103 CHGD VALUES R-144 WAS 560Ω, 3W AND R-200 WAS 10K
H	1-11-61	JRC	REVISED CKT

F. L. MOSELEY CO.
PASADENA CALIFORNIA

TOLERANCE UNLESS OTHERWISE SPECIFIED:
FRACTIONAL: ± 1/64 DECIMAL: ± .005 ANGULAR: ± ½°
REMOVE BURRS AND BREAK SHARP EDGES
DO NOT SCALE DRAWING - WORK FROM DIMENSIONS ONLY

TITLE: SCHEMATIC-MODEL 3S & 5S

MAT'L:			
FINISH:			
DR: FAH	5,5,58	SCALE:	
CK'D:		DATE:	5,5,58
APPR: AOH	7.9.58	NEXT ASS'Y:	
USED ON: MODEL 3S,5S		PART NO.: D4650	REV.: I

THE MOSELEY